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Cross-Modulation Compensator

By KURT SINGER
and R. V. McKIE

This device permits the production of direct-positive variable-area recordings of higher densities and lower cross-modulation distortion than hitherto possible. This is accomplished by pre-distorting the recorded signal electrically so as to cancel the cross-modulation components produced by image spread due to the use of high track densities.

In order to gain a better understanding of the accomplishments of the device described in this paper, let us review briefly some well-known facts. A variable-area soundtrack is fundamentally nothing more than an oscillographic trace of the original sound wave, having all the area on one side of the trace transparent, and all the area on the other side opaque. Although there are various forms of soundtracks, such as uni-lateral, bi-lateral, push-pull, etc., they are all designed to accomplish the same final result, namely, to vary the light intensity that reaches the photocell in the reproducer, in accordance with the original sound wave. Due to the characteristic of photographic materials, complete opacity and transparency are impossible, but it is not difficult to obtain a density contrast that will satisfy all practical requirements. The quest for high density contrast is dictated by the desire to produce a high signal-to-noise ratio. Another requisite of a good variable-area sound record is that the silver image must be exactly the same size and shape as the optical image that formed it.

It is characteristic of all photographic materials to diffuse the light that penetrates their surfaces. The degree of diffusion varies with different types of emulsions, the wavelength of the exposing light and the angle at which the light strikes the emulsion. In addition, the silver image is also affected in sharpness and size by the type of development. The effect of this diffusion on the exposure for any small unit area, is that the total exposure in this area is dependent on the exposure of the adjacent areas. It follows therefore that the boundary of the silver image lacks sharpness and may be larger or smaller than the optical image. On soundtrack prints where the unit areas are comparatively large, as is true of the lower frequencies, the image spread is of negligible importance. However, at the higher frequencies the image spread becomes an important factor. Image spread introduces distortion, since it alters the average transmission of high frequency waves. After taking advantage of all the factors which reduce the image spread, the silver image on a print of a density of 1.4 is still larger than the optical image that formed it. Consequently, in order to produce the correct silver image on the print, it is necessary to introduce a compensating factor (image spread) into the negative. That is, the silver image on the negative must be larger and therefore the clear portion smaller by the amount of image spread in the print, so that when the negative is printed, the silver image on the print will be exactly the same size and shape as the optical image that exposed the negative. The effects of uncontrolled image spread on the reproduction of sibilants are well known in the industry. They are easily recognized as an audible distortion which makes sibilants sound rough and broken up.

So far, we have been dealing only with the production of variable-area sound records by recording negatives and making positive prints. A compensating image spread has been introduced into the negative and/or print, in order to obtain a final result containing a minimum of distortion. However, when producing a direct-positive variable-area sound record, the possibility of introducing cancelling image spreads in the negative and/or print does not exist, since the direct-positive record itself must correspond to the final product. That is, the direct-positive record must be equivalent to a good print in the negative-positive recording system.

Let us enumerate the limitations that have been encountered in the past when recording direct-positive variable-area soundtracks. As pointed out just previously, these types of soundtracks concern only one film, and consequently cannot be corrected for sibilant distortion in the usual manner. The balance density, as measured by the conventional cross-modulation test[1] for the best obtainable single film emulsions for acceptable low distortion is very low, in the order of 0.6 or 0.7. When recording at these low densities, the signal output from the tracks is too low and excessively noisy.

On the other hand, if one exposes for a density which results in increased output level and improved signal-to-noise ratio, then excessive sibilant distortion occurs. Since sibilant distortion, as mentioned previously, is caused by filling in of the photographed wave pattern, due to image spread at high densities, a method is hereby described which permits adding an electrical signal to the recorded signal that will tend to compensate for this distortion when soundtracks are developed to higher than balance densities. It has been found that it is possible to modify the shape of an optical image so that when recording direct-positive photographic soundtracks the changes in the optical image can be dimensioned in such a manner as to counteract the distortion introduced by the image spread incurred by the light scatter and processing of the emulsion.

When image spread occurs, the decrease in average transmission of a high-frequency signal is proportional to its amplitude and is some function of frequency, in general increasing as frequency increases. If a compensating signal is derived by passing the original signal through a filter having the appropriate rising frequency characteristic, and then rectifying it, this new wave can be fed into the galvanometer as a bucking signal. By adjusting the amplitude and phase of this corrective signal, it is possible to arrive at a value which provides optimum cancellation of the image spread or cross-modulation effect.

The first step in the procedure for determining the proper compensation distortion was to determine how much correction was needed at each frequency at various densities. A number of different methods were tried with varying degrees of success, but fortunately all of them indicated the same sort of curve, proving beyond reasonable doubt that the curve that was obtained was correct. While it is deemed to be beyond the scope of this paper to explain in detail how this curve was derived, Fig. 1 shows the required compensating current for 80% and 50% modulation for a density of 1.3. This is a typical curve which is subject to minor variations due to processing conditions.

It was thought at first that the corrective signal which is introduced had to effect a wave-by-wave correction of the signal in order to produce beneficial results. While this assumption is true in theory, it was also found that it was impossible to achieve this in practice. Two chief obstacles were encountered: (1) phase shift between the original signal and the corrective signal and (2) the limited frequency characteristic of the galvanometer which prevents the recording of frequencies above 9000 cycles. This low-pass filter effect limits the recording of second harmonics to fundamental frequencies of a maximum of 4500 cycles.

Since in spite of these enumerated

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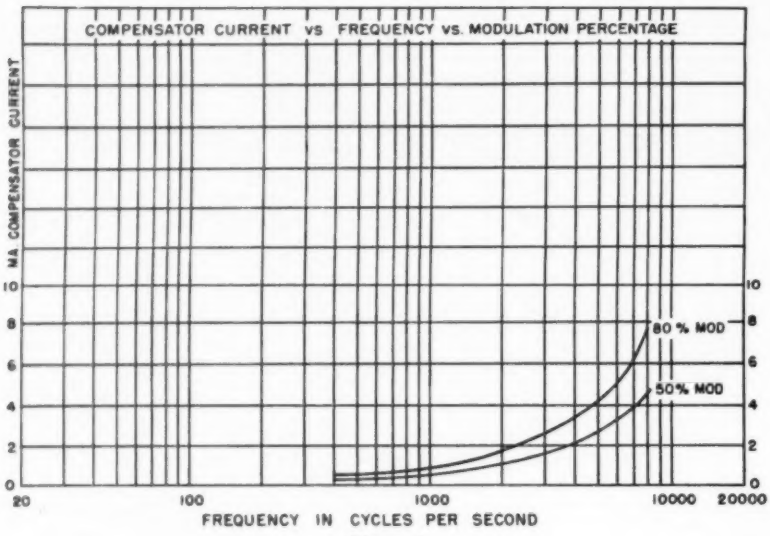
COMPENSATOR CURRENT VS FREQUENCY VS. MODULATION PERCENTAGE
MA COMPENSATOR CURRENT
80 % MOD
50% MOD
FREQUENCY IN CYCLES PER SECOND

Figure 1

limitations good correction of cross-modulation distortion was obtained, an explanation was sought. If one remembers that the presence of cross modulation reduces the average transmission of a high-frequency wave, and if one applies this thought to what happens to a 9000-cycle carrier which is amplitude modulated with 400 cycles, one finds that this change in average transmission due to rectification produces 400 cycles, which is the frequency difference between carrier and sidebands.

Since the presence of this type of rectification product is responsible for the objectionable quality change which is experienced when zero shift (cross modulation) occurs, it can be reasoned that if a quality improvement is obtained with the cross-modulation compensator, corrective means are introduced during the recording which cancel the rectification products generated during film processing. The rectifier in the cross-modulation compensator generates the usual rectification products, consisting of sum and difference frequencies of the fundamentals and harmonics. Since the galvanometer does not respond to frequencies above 9000 cycles, most of the sum frequencies in the rectification products cannot contribute anything to the corrective signal that is recorded. It can be safely assumed that the difference frequencies of the fundamentals occurring in the rectification products provide the beneficial components of the corrective signal which, when applied to the galvanometer in correct phase relation and amplitude, provide a corrective signal envelope which cancels the distortion product envelope generated during processing.

It is admitted that if cross-modulation correction would have to depend on a wave-by-wave correction, it would be impossible to obtain practical results, due to the stringent phase requirements. However, since only approximately correct phasing of the corrective signal envelope is required, cross-modulation correction is within the realm of practicability, as a satisfactory reduction of zero shift can be effected by having the corrective signal of proper amplitude approach a 180° phase shift.

Figure 2 is a block schematic of a recording system employing the cross-modulation compensator. It can be seen that the recording channel setup is conventional in all respects, except that the input for the cross-modulation compensator is obtained essentially at the same point where also the noise reduction amplifier input is derived. This recording channel employs biased galvanometer type of noise reduction, which is a requirement when producing direct-posi-

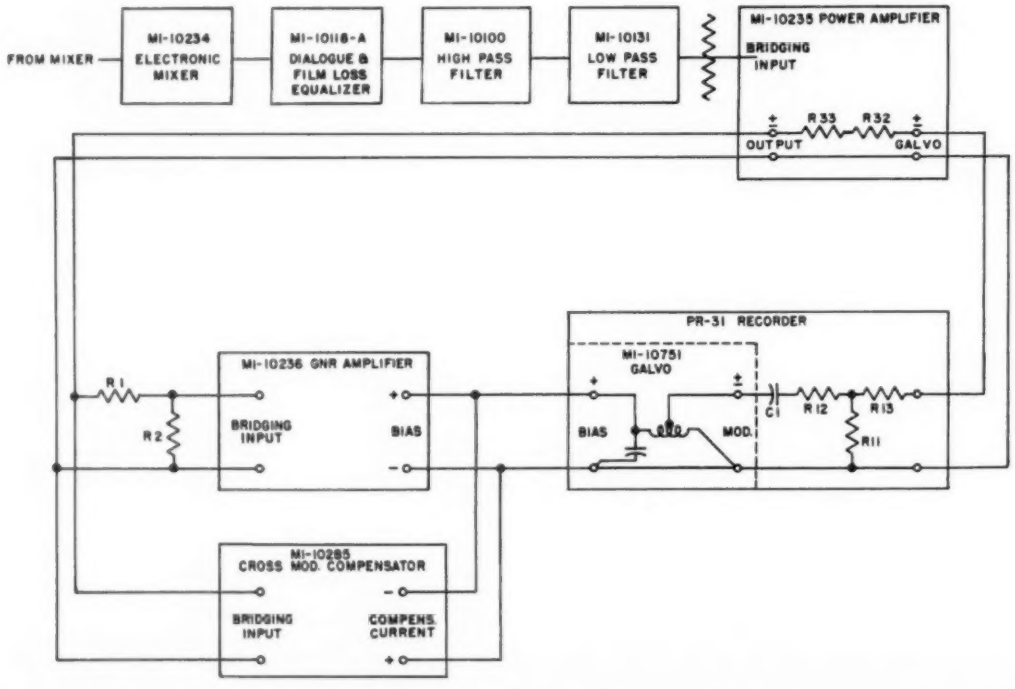

Fig. 2. Block schematic of typical recording channel using cross-modulation compensator.

tive tracks. The output of the cross-modulation compensator is connected in parallel with the output of the noise reduction amplifier in such a manner that the cross-modulation compensator output current bucks the noise reduction current. Thus, since the noise reduction current decreases with increased amplitude, the cross-modulation compensating current increases. This is in line with the previously explained requirement that the cross-modulation compensating current has to be proportional to signal amplitude.

The circuit of the cross-modulation compensator proper is illustrated in Fig. 3. A sampling of the signal to be recorded is applied to a bridging transformer, the secondary of which is terminated with a suitable volume control. This signal, adjusted for amplitude, is then applied to the grid of a cathode follower through a frequency selective network, the output of which contains the frequency correction illustrated and explained earlier in this paper. The slope of the frequency characteristic is 6 db per octave. It also serves to attenuate all frequencies below 500 cycles.

The output of this compensating network is applied to the grid of a two-stage amplifier with negative feedback from the output tube plate to the input tube cathode. Negative feedback is used to lower the plate impedance of the beam power tube, V2, to improve the linearity and to stabilize the gain. The output of V2 feeds a rectifier transformer, the secondary voltage of which is in turn applied to the plates of a full-wave rectifier tube. The output of this rectifier is developed across R14, and is applied without filtering to the grid of a d-c amplifier, V4. This d-c amplifier provides a high impedance output from the cross-modulation compensator so as not to load the galvanometer to which it will be applied. The zero signal plate current of V4 has been reduced to a very low value by the application of a high negative grid bias. The unbypassed cathode resistor introduces a sufficient amount of current feedback so as to maintain input-output linearity over the required working range.

As can be seen, the output of the rectifier is applied to the grid of the d-c amplifier without any filtering. This was found quite necessary in order to avoid the introduction of detrimental phase shifts. In fact, an earlier version of this circuit employed filtering of the rectifier output. However, preliminary tests proved beyond doubt that the presence of this filtering introduced phase shifts which prevented successful operation of this earlier device.

The technique of adjusting the cross-modulation compensator is as follows: At first a series of lamp current tests is made and processed to determine the correct recorder lamp current for the desired track density. Let us assume this track density is 1.6. This selection was made from considerations of freedom from noise and sufficient output level. After the lamp current tests have been processed, densities measured and the correct lamp current determined, a family of cross-modulation recordings with various cross-modulation compensator currents is made. A method that has proven successful in practice is to keep the track modulation percentage constant, and to vary the input volume control on the compensator. The following frequencies are then recorded: 1000 cycles for reference level, 8000 cycles for high-frequency attenuation measurements, and 8000 cycles amplitude modulated 80% at 400 cycles for cross-modulation measurements. The galvanometer modulation is kept constant at 80% at 1000, 8000, and at 8000 cycles modulated with 400 cycles. The range of compensating currents over which these tests are usually run is from approximately 4 to 11 ma in 1-ma steps. The compensating current is always set at 8000 cycles for reasons explained later in this paper.

After processing, the cross-modulation frequency content, namely 400 cycles, is measured. From these measurements the compensator current which produces minimum cross modulation is then selected. Let us assume that a compensator current of 5 ma at 8000 cycles produces minimum cross modulation. The recording channel gain and cross-modulation compensator gain are then adjusted so that 80% modulation of the galvanometer at 8000 cycles produces a compensator current of 5 ma. The frequency of 8000 cycles has been selected since it lies below the resonant frequency of the galvanometer. Furthermore, once the optimum compensator current has

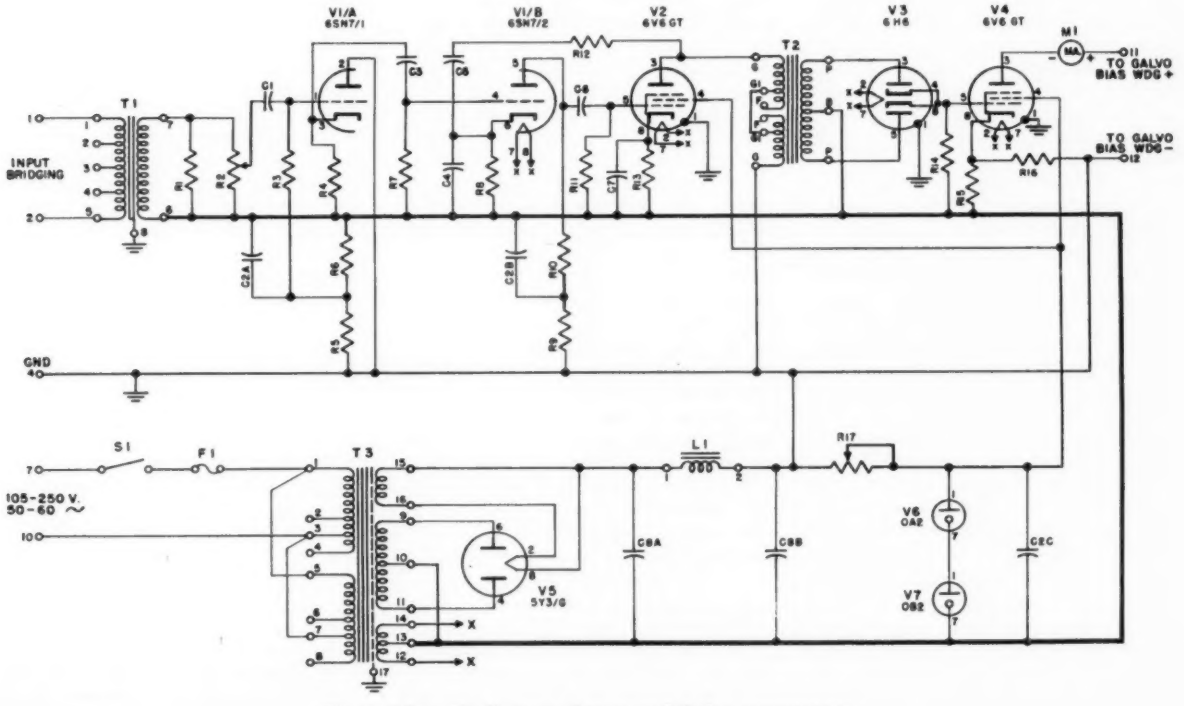

Fig. 3. Schematic diagram of cross-modulation compensator.

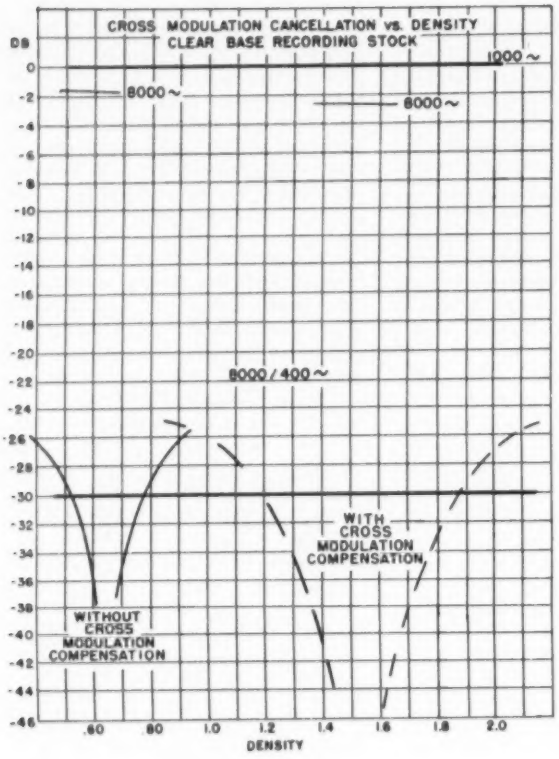

Figure 4

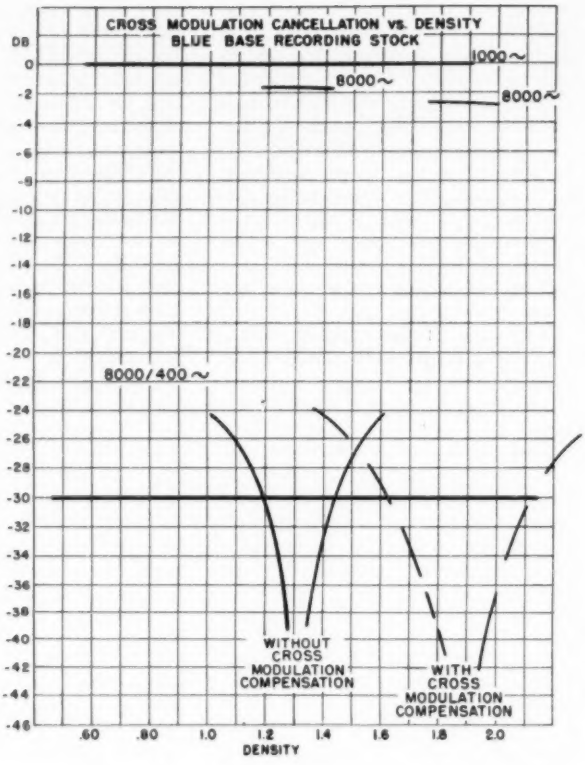

Figure 5

been found, all other cross-modulation compensators of similar recording channels in a studio can be adjusted at 8000 cycles, provided the processing conditions are the same. Also, being able to adjust the compensator at 8000 cycles presents an operating convenience, since audio oscillators are usually readily available in most installations, whereas there might be only one modulated carrier oscillator in a studio located remote from the various recording channels, and not always conveniently available for instantaneous use.

By adjusting channel and compensator gain in the above outlined manner, the compensator adjustment is independent of recording channel frequency characteristic, since any change in channel frequency characteristic is automatically reflected into the cross-modulation compensator, as it is connected at the output of the recording channel.

After the optimum compensator current has been found, it is advisable to record dialogue tests. One take should be made at the exact compensator current that was determined to be the best from a consideration of minimum cross modulation. Several additional dialogue tests, however, should be made, using slightly higher and lower compensator currents to evaluate whether the measurements results actually correspond to practice. In some cases it was found that corrections of cross-modulation compensator current of about 1 ma, up or down, produced a slight improvement.

Before putting the experimental model of the cross-modulation compensator on actual production, direct-positive recordings were exposed with white light on clear base and blue base recording stocks, normally used for variable-area negatives, and developed in a high contrast soundtrack negative to a gamma of 3.5. The densities of the direct positive were measured with a Western Electric RA-1100B densitometer, using a visual filter. The cross-modulation tests were measured on a calibrated reproducing system. Figures 4 and 5 show cross-modulation curves plotted against the density of the direct positive, exposed on clear base and blue base recording stocks, respectively. Since it has been established by numerous tests that 30-db cancellation of the 400-cycle component in cross-modulation tests is satisfactory for all types of material, density tolerances have been established at this cancellation value. From these curves and listening tests, it was evident that the density of the direct positives exposed on clear base recording stock could be increased from 0.7 to 1.5 when using the cross-modulation compensator at a compensator current of 5 ma at 8000 cycles.

The density of the tracks recorded on blue base stock could be increased from 1.3 to 1.9, using again a compensator current of 5 ma.

This increase in track density that can be gained with the use of the cross-modulation compensator makes, in some instances, the difference between marginal dialogue quality due to low density values and exceptionally good dialogue quality when the cross-modulation compensator is used.

Several models of the cross-modulation compensator have been used in production over the past year, with very satisfactory results. It must be admitted, however, that the execution of cross-modulation compensation as outlined in this paper does not always strictly adhere to the precepts of theory. It should be mentioned in particular that the compensating current produced in this device is *directly* proportional to the amplitude and frequency of the recorded signal, whereas it can be shown by calculation that the magnitude of compensating current for optimum compensation is not strictly a linear function. However, this device represents an exceptionally well working practical compromise which has been invaluable in improving the quality of direct-positive variable-area recordings.

Credit is hereby given to the Advanced Development Group of the RCA Victor Division in Camden, N.J., which, under the direction of Glenn L. Dimmick, has done the basic work on the cross-modulation compensator.

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1. J. O. Baker and D. H. Robinson, "Modulated high frequency recording as a means of determining conditions for optimal processing," *Jour. SMPE, 30:* 3–17, Jan. 1938.
2. Glenn L. Dimmick, U.S. Patent 2074049, Mar. 16, 1937.
3. Frederick G. Albin, U.S. Patent 2587081, Feb. 26, 1952.
4. A. C. Blaney and Kurt Singer, U.S. Patent 2647169, July 18, 1953.

Discussion

Richard H. Ranger (*Rangertone, Inc.*): Is this all 35mm?

Mr. Ancona: The slides which were shown were based on 35mm tests; however it has been used at NBC in Hollywood over the past year, I believe, on 16mm recordings. It is applicable to 16mm work and there is data in our engineering files on this.

Col. Ranger: And can you give us the figure of what cross-modulation cancellation you get on 16mm?

Mr. Ancona: I don't have those figures here. I wasn't involved in this work. I think they are of the order of what you can get with good 16mm prints. The improvement is substantial.

Joseph E. Aiken (*Naval Photographic Center*): If one has a direct positive or print already made, which has cross-modulation distortion, and it is played back, or reproduced on a re-recorder or dummy, would the cross-modulation compensator be effective in reducing distortion already on the print?

Mr. Ancona: I would say no. To subtract distortion of the cross-modulation type from a recording which already exists, would be impossible, I should say. The compensator must be employed during the actual exposing of recording stock.

[*Note the following advice given by correspondence from the authors, subsequent to the Convention*]:

[Since presentation of this paper before the Society, we have made additional tests in order to arrive at a satisfactory answer to Mr. Aiken's question as to whether it would be possible to correct a direct positive or a print which contains cross-modulation distortion by the application of the cross-modulation compensator during playback. Our tests have shown that such correction is feasible. We have obtained as much as 14-db reduction of 400-cycle output from a print which contains a 9000-cycle modulated with 400 cycles recording which measured only 23-db cancellation. While this 14-db improvement still is not the optimum, it represents a substantial and very useful gain in practice.

[We have also made tests using speech recordings containing cross modulation and have also found a substantial audible improvement through application of the cross-modulation compensator. We feel, however, that in order to use the corrective capabilities of the cross-modulation compensator to its fullest extent for the improvement of existing prints or direct positives, additional work on our part will be required.]

George Lewin (*Signal Corps Pictorial Center*): Can you tell us whether this has been used with any beneficial results in recording direct positives for subsequent printing to color release prints?

Mr. Ancona: The direct positive that is used in printing color is, functionally speaking, a negative and would have to be treated as such as far as analyzing its effect on distortion. You could not use this compensator in recording a negative, or, in the case of your question, a "printing" direct positive, because it would add to the eventual distortion, or rather, it would require a lower print density. Take the black-and-white case, if we are using a cross-modulation compensator to record a variable-area negative, the cross-modulation compensator would reduce the apparent image-spread distortion on the negative and therefore we would require a print of less density than we would have with an uncompensated negative. This is not in the direction we are striving to go. The whole effort in the use of this compensator is to produce a print record of higher density and therefore lower noise. So, offhand, I would say that this compensator would have no application in recording negatives or "printing" direct positives.

Mauro Zambuto (*Italian Films Export*): My question is based on certain experiments that have been made in a completely different field but that are something like this. I would like to know, have you run any inter-modulation tests or any other tests that would tell you what happens in odd harmonics because in these experiments that I mentioned, some trouble was experienced by the fact that a certain amount of odd harmonics were introduced by a system of this sort.

Mr. Ancona: You mean there are odd harmonics introduced by image spread?

Mr. Zambuto: No. By trying to cancel certain even harmonics through a system of this kind, it so happened that we were introducing odd harmonics, that is, while the cross modulation was actually improving, there was no overall improvement. Contrariwise, there was a rather bad effect on the inter-modulation.

Mr. Ancona: In compensating for image-spread distortion in variable-area recording, we are essentially correcting what is known as envelope distortion and are not concerned with individual waves; therefore, the chief correction component that this compensator puts out is subharmonically related to the signals rather than harmonically related, so that this would have, I would say, no bearing on the point you bring out. We're not concerned with cancelling individual distortion harmonics of the recorded signal. We're concerned with subharmonics. In fact, these envelope products which we are attempting to cancel are, for the most part, not harmonically related to the signal.

Mr. Zambuto: I see. In any case, you didn't run any tests that would show this phenomenon, for instance, what happens in intermodulation — or did you make measurements of that kind?

Mr. Ancona: No. In fact, on variable-area recording the intermodulation test is of very low sensitivity. It is of no practical use in assisting in variable-area processing, so we would have no results or inter-modulation tests as opposed to cross-modulation tests.

Theater Loudspeaker System Incorporating an Acoustic-Lens Radiator

By JOHN G. FRAYNE
and B. N. LOCANTHI

This paper describes a two-way loudspeaker system having an extended frequency range and exceptionally uniform distribution. These characteristics, which effectively meet the requirements for the presentation of stereophonic sound in motion-picture theaters, are obtained by the use of an acoustic lens. Spherical and elliptical lens elements accommodate the distribution pattern to variously shaped auditoria. Design features of the low-frequency horn provide a clean response which is essentially free from resonance.

THEATER loudspeaker systems have been steadily improved through the past years so that, for single-channel operation, the audience receives an impression that it is listening to a reasonable likeness of the original sound. This has been pointed out in a paper previously presented before the Society.[1] This steady improvement in performance has been achieved largely by technical advancements in the design of driver units and in the case of the low-frequency speaker by the replacement of folded horns with short, front-loaded horns.

The advent of stereophonic and pseudostereophonic presentation in the theater has introduced new requirements which call for a re-examination of loudspeaker performance.[2] In stereophonic presentation, exceptionally uniform distribution of high frequencies is particularly desirable in order to obtain a realistic auditory perspective. If loudspeakers have a high-frequency distribution characteristic which varies materially with frequency or if there are sizable level changes over the angle of distribution, the localization of the apparent source of sound will appear to be different from various points in an auditorium.

Since fidelity in stereophonic localization is almost entirely attributable to the upper register of the frequency spectrum, the major problem is the design of satisfactory high-frequency sound-dispersing mechanisms. In approaching this problem, it was arbitrarily decided that two types of units, one having 50° and the other 80° horizontal distribution, would be provided. Using two of either of these units provides 100° or 160°, respectively, of horizontal coverage. The vertical coverage in all cases was set at approximately 50°.

The high-frequency driver unit is of the permanent-magnet type and provides approximately 21,000 gauss at the voice coil. The diaphragm is approximately 4 in. in diameter and is of 0.003-in. thick aluminum. A typical power-output curve of the driver unit is shown in Fig. 1. This curve was made by measuring the sound pressure at the sending end of a tube which was filled with a long, tapered, sound-absorbent wedge and which was driven by the high-frequency unit. The sound-measuring device was a 640AA microphone. The results of this test are believed to be accurate to approximately 9 kc.

For uniform distribution over the required angles of auditorium coverage, the principle of the acoustic lens has been employed. This involves the use of a type of structure which refracts and diverges sound waves and is similar in function to certain electromagnetic-wave lenses in that it consists of arrays of obstacles which are small compared to the wavelengths involved. These obstacles create an effect which is equivalent to increasing the effective density of the air which results in a reduced propagation velocity of sound waves passing through the array. This reduced velocity is synonymous with refractive power, effecting a refractive index higher than unity. The theory of this type of lens is ably set forth in a paper by Winston E. Kock and F. K. Harvey of the Bell Telephone Laboratories.[3]

Several types of acoustic lenses have been described[3] and of these, two are used — a perforated-disk type having an index of refraction of about 1.2 which provides a horizontal-distribution angle of 50° and a slant-plate type having an index of refraction of about 1.5 which is easily capable of providing a horizontal-distribution angle of 80°. By using two of either type of lens, the horizontal coverage is increased to 100° or 160°, respectively. In all cases the vertical-distribution angle has been set at approximately 50°.

It may be well to discuss briefly the principle of operation of the two types of lenses currently being used. The first depends upon increasing the effective density of the sound-transmitting medium within the boundaries of the lens. Refraction occurs in media consisting of arrays of individual discrete particles, providing that the particles and distances between them are small compared to the wavelength of the wave propagation under consideration. In other words, if an array of small, rigid particles, having infinite mass for our acoustical consideration, is set up in space, the combination of rigid particles immersed in air results in a new medium having an index of refraction which is greater than unity. Since the velocity of propagation of sound is inversely proportional to the square root of the density of the medium, it will be less through an obstacle array than in free air. Depending on the profile or shape of the obstacle array, the sound waves can be focused or diverged as desired. This obstacle-array type of lens is limited for practical reasons to an index of refraction of about 1.2. A series of perforated metal plates, properly shaped and spaced, can provide similar lens effects and is suitable for loudspeaker applications where the required angle of distribution is not excessive.

Another method of slowing down a progressive wave is to guide it through a conduit or the equivalent, which provides a longer path than that which the unguided wave would normally take. Thus, if a series of parallel plates of varying length are tilted at an angle to the direction of propagation, a delay will

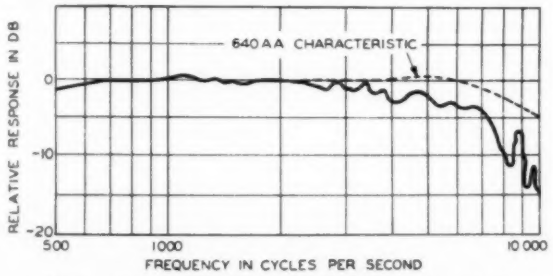


Fig. 1. Power-output curve for T530A loudspeaker.

Presented on May 5, 1954, at the Society's Convention at Washington, D.C., by John G. Frayne (who read the paper), Westrex Corp., 6601 Romaine St., Hollywood 38, and B. N. Locanthi, Consultant, 2552 Boulder Rd., Altadena, Calif. (This paper was received on June 4, 1954.)

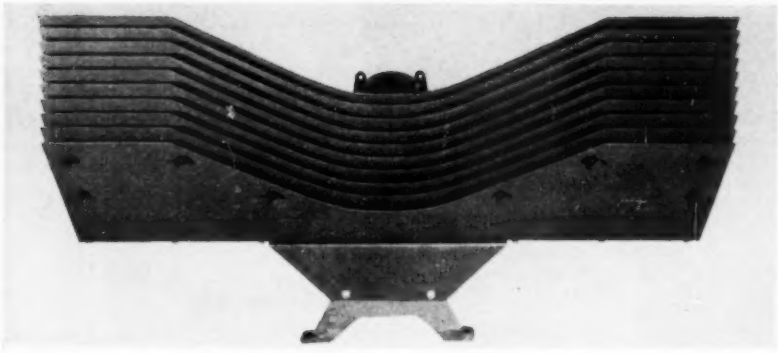


Fig. 2. Front view of T551A acoustic lens assembly.

be produced since the waves will be forced to traverse the longer inclined path. It is then a question of shaping the plates to obtain the desired type of lens action. The effective index of refraction, n, can be shown to be equal to the reciprocal of the cosine of the angle between the slanted plates and the direction of the oncoming wave. In such path-length devices, n remains constant with frequency to a point where the plate spacing approaches a half-wavelength, and an index of refraction up to 1.5 is readily achieved.

Figure 2 shows such a lens designed to give 80° of coverage horizontally and 50° of coverage in the vertical direction. To obtain this type of coverage calls for a bicylindrical lens which is obtained by shaping the individual plates in accordance with the following:

The final surfaces of the refracting lens are determined empirically; however, the first approximation involves the following calculation of an aplanatic surface which will convert a plane wave to a spherical wave:

Referring to Fig. 3, let F represent the point on the axis of the lens from which all refracted rays will appear to be radiated. The distance from the curved surface on the axis to the apparent focal point is represented by f, and t is the thickness of the lens at the narrowest point.

Since S_1 is plane and normal to the incident plane wave, the incident rays are undeflected after entering the first surface.

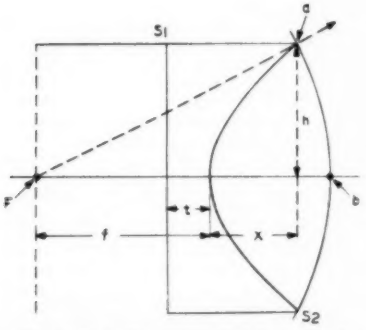


Fig. 3. Ray diagram. Medium of index n between surfaces S_1 and S_2. Index of refraction unity outside S_1 and S_2.

In order for an incident ray entering the lens at some arbitrary distance, h, from the axis of the lens to appear to have come from F after leaving surface S_2, the time required to travel from F to a should equal the time required for an axial ray to travel from F to b. That is:

$$\frac{f-t}{v_0}+\frac{nt}{v_0}+\frac{\sqrt{(f+x)^2+h^2}-f}{v_0}=\frac{n(t+x)}{v_0}+\frac{f-t}{v_0}$$

which simplifies to

$$(n^2-1)x^2+2fx(n-1)-h^2=0$$

which is a hyperbolic surface.

These calculations produce an idealized acoustic lens, the plates of which must be modified in shape empirically to produce the desired overall results. Experience has further shown that closing the sides of the plates introduces sizable irregularities in the frequency response. On the other hand, with the sides open, the plates must be extended horizontally for a minimum of some 5 or 6 in. beyond the curved edges of the plates to obtain a smooth frequency response with uniform angular distribution.

The driver unit is coupled to a short elliptical horn terminated in a bicylindrical slant-plate lens. Figure 4 shows the results of tests made under open-air conditions at 10 kc on the horizontal axis with and without a cylindrical lens. This gives a fairly good idea of the refracting power of the lens.

Figure 5 shows the horizontal distribution of an 80° horn assembly at four frequencies as measured under open-air conditions. Similar measurements of the vertical distribution are shown in Fig. 6. The horizontal distribution of the same unit as measured on a studio sound stage is shown in Fig. 7. Warble tones were used in this case and the curves shown are of the average response. The sound-stage measurements and the equivalent open-air measurements will be found to be in close agreement.

By way of comparison, Figs. 8 and 9 show the horizontal and vertical distribution of a typical 2 × 5 multicellular theater-type horn, measured under open-air conditions. The rather sizable lobes in the distribution characteristic are apparently typical of this type of loudspeaker and are particularly undesirable for stereophonic reproduction.

The 50° acoustic lens employs the principle of the obstacle array in the form of perforated plates. Since the horizontal and vertical distribution angles are the same in this case, a horn having a circular cross section is used. Figure 10 shows this type of lens. The driver unit is the same as that used with the 80° unit. The distribution curves obtained with this unit are substantially similar to those obtained with the 80° lens except for the smaller angle of horizontal coverage. Here again, as in the case of the slant-plate lens, closing the sides of the perforated plates introduces a rise at the upper end of the frequency response as well as a too rapid falling off of the angular distribution with increase of angle from the axis of the lens. These undesirable factors have been corrected by introducing rectangular openings in the side walls of the casting in which the perforated plates are mounted.

The very low frequencies of the audible spectrum contribute essentially nothing to stereophonic localization. The design problems pertaining to low-frequency horns are therefore the same as those for single-channel reproduction; namely, the design of the driver units and the coupling between these units and their horn.

For the systems under discussion, two low-frequency horn systems have been developed, one equipped with two driver units and one with four driver units. These consist essentially of short front-loaded horns having efficiencies of approximately 25%. In order to avoid high-frequency attenuation due to an air volume between the driver diaphragm and the horn throat, the ratio of the diaphragm area to the horn-throat area has been kept at 1:1. In order to minimize distortion at low frequencies, the voice coils of the drivers overhang the pole pieces by about 20%. A theoretical response curve for a four-driver, low-frequency horn assembly is shown in Fig. 11.

The dividing network which couples the low-frequency and high-frequency horn assemblies to the amplifier output has a crossover at 500 cycles with a 12-db/octave attenuation on both sides of this point. The network input and output impedances are 16 ohms. In the 50-w horn system one network serves to couple one high-frequency and two low-frequency drivers. In the 100-w horn system, two networks are employed to couple two high-frequency and four low-frequency drivers.

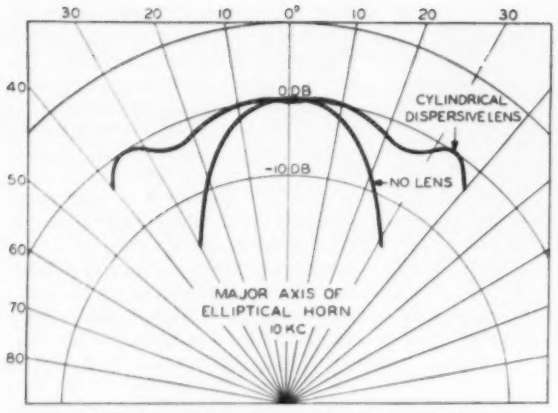


Fig. 4. Effect of acoustic lens on horizontal distribution.

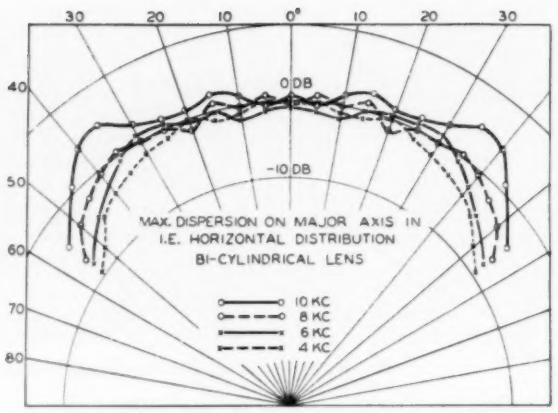


Fig. 5. Horizontal distribution of slant-plate acoustic lens assembly — open-air measuring conditions.

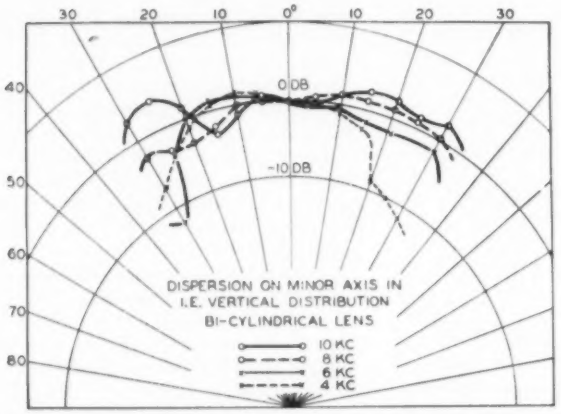


Fig. 6. Vertical distribution of slant-plate acoustic lens assembly — open-air measuring conditions.

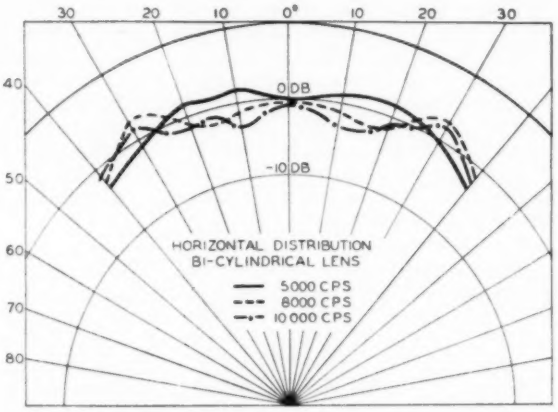


Fig. 7. Horizontal distribution of slant-plate acoustic lens assembly — measured on sound stage.

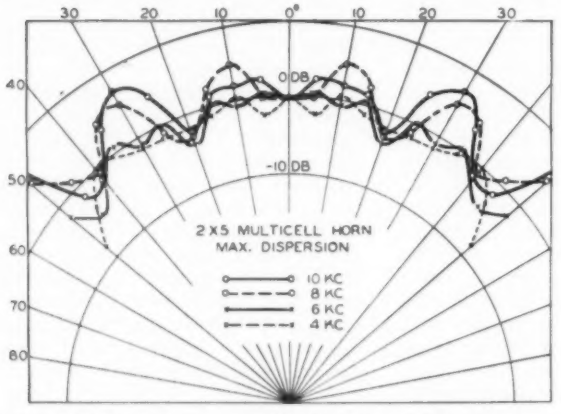


Fig. 8. Horizontal response of typical 2 × 5 multicell theater horn — open-air measuring conditions.

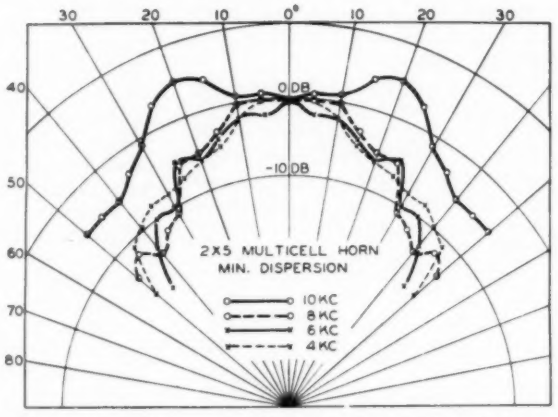


Fig. 9. Vertical response of typical 2 × 5 multicell theater horn — open-air measuring conditions.

A view of a 100-w loudspeaker system consisting of a low-frequency horn equipped with four driver units and two 80° acoustic lens assemblies is shown in Fig. 12. The response characteristic of a 50-w loudspeaker system, using two low-frequency driver units and one 80° acoustic lens system, is shown in Fig. 13. This curve represents a smoothed average of warble-tone measurements taken on the horn axis on a studio sound stage. Corrections have been applied for the characteristic of the measuring microphone and the scale is substantially similar to that used on the charts of the usual types of sound-measuring equipment.

Listening tests using program material have been very gratifying. No low-frequency resonances were observed and the high-frequency tones were exceptionally clean. The horizontal distribution was observed to be in conformance with the curves previously shown. When compared with a conventional theater loudspeaker system under A-B test conditions, the new system brought the

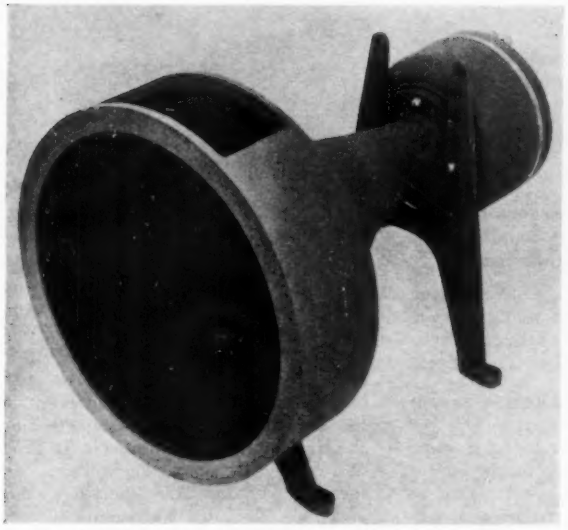


Fig. 10. Front view of T550A acoustic lens assembly.

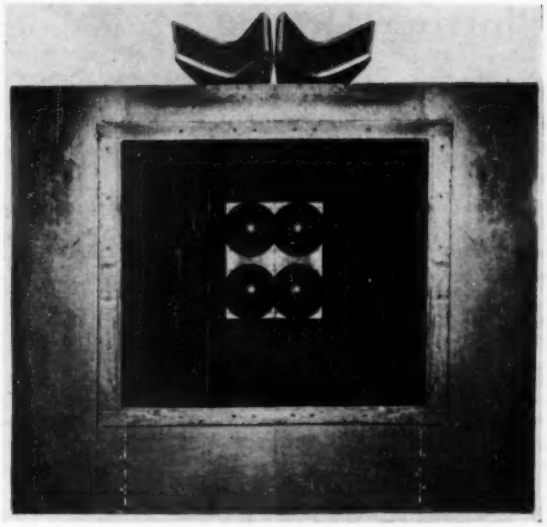
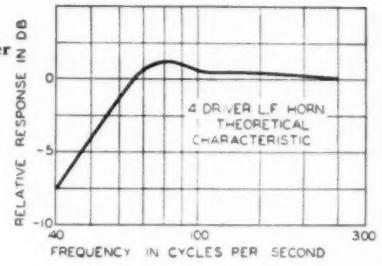


Fig. 12. View of T502B loudspeaker system.

Fig. 11. Theoretical response of four-driver low-frequency horn assembly.



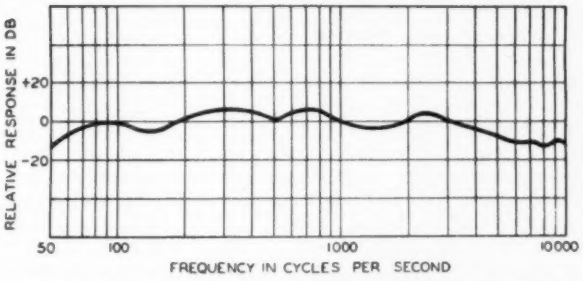


Fig. 13. Response characteristic of 50-w system — smoothed average warble-tone measurements.

apparent source of sound considerably closer to the audience, thus indicating a desirable presence factor.

References

1. J. K. Hilliard, "Theater loudspeaker design, performance and measurement," *Jour. SMPE, 52:* 629–640, June 1949.
2. William B. Snow, "Basic principles of stereophonic sound," *Jour. SMPTE, 61:* 567–589, Nov. 1953.
3. Winston E. Kock and F. K. Harvey, "Refracting sound waves," *J. Acoust. Soc. Am., 21:* 471–481, Sept. 1949.

Discussion

John Hilliard (Altec Lansing Corp., Calif.): In one of the slides you showed a round, diffusing-type horn system. How does that compare with the one of the rectangular type?

Dr. Frayne: The curves are quite similar over their respective design angle of distribution. I'm sorry we don't have a curve on it here. It was designed for 50° distribution. At 25° off the axis the response was falling off.

Mr. Hilliard: By coincidence, I happened to measure two or three of them and found that whenever you take the lens properties out of it, the directional properties increase, that is the frequency response was extended and the drop-off with azimuth was less than it was with the lens assembly on it.

Dr. Frayne: That's not in accordance with measurements shown in Fig. 4.

Mr. Hilliard: This was a general statement that in all cases when the diffuser element was taken off the properties of the two units measured were improved and these were measured in an anechoic chamber with the 640AA microphone as the standard.

Dr. Frayne: I wouldn't want to dispute your word, but I don't think it agrees with our findings.

M. A. Kerr (Bureau of Ships): You said in the beginning of your paper that the spread of sound at the high frequencies was necessary for the spatial illusion and this work that you're showing begins at the high-frequency end and works downward. That would assume that there is a crossover point where the spatial illusion effect is no longer necessary, because I don't see any similar spread in your low-frequency units. Is there any critical frequency point or general area where it is no longer necessary to properly spread the low frequencies?

Dr. Frayne: According to Snow[3] very poor localization is obtained below 1000 cycles.

John Volkmann (Radio Corp. of America, Camden, N.J.): Your paper did not show any directional characteristics for the low-frequency speaker?

Dr. Frayne: No.

Mr. Volkmann: Does it match the directional pattern of the high-frequency speakers? In particular, how does the directional pattern of the combined systems act in the crossover frequency range?

Dr. Frayne: The 50-cycle distribution is very uniform. The 500-cycle distribution of the low-frequency speaker measures essentially the same as that obtained from the lens. I would say that the performance of the low-frequency system is quite comparable to any 50- or 100-w system today in theaters. The thing we're trying to emphasize here is the lens of the high-frequency units.

Mr. Volkmann: I'd like to point out that there is a fundamental difference in the design of the low-frequency horn relative to the high-frequency horn, namely, if I judge the design correctly, the low-frequency horn is designed on a basis of a plane-wave progression in the horn.

Dr. Frayne: That's right.

Mr. Volkmann: In a straight-axis exponential horn design the plane wave radiation would tend to give a sharpening of the directional pattern with an increase in frequency, whereas the high-frequency horn design, being based on the lens principle, the radiation would tend to give a spherical distribution of the sound within its angular range and there would be, in the crossover region, then, a disparity between the two types of directional patterns.

Dr. Frayne: Well, I've seen curves on both the 50-w and 100-w systems covering the angles we mention here. There were no signs of such disparity.

Mr. Volkmann: My second question is whether or not you really desire a spherical distribution pattern in the vertical angle, where, for example, in an auditorium you want the same level in the front rows of seats as in the back rows? Except where the loudspeakers are up high enough, is it not more desirable to have a sharp directional pattern in the vertical plane in order to balance the level from front to back more uniformly?

I would like to make another point. The low-frequency horn has a very similar likeness to one of the models (straight axis) that RCA tested in connection with the experiments that were conducted by Douglas Shearer back in 1935 or 1936.

Dr. Frayne: I believe the model you were referring to was a folded-type horn while the present unit is a short front-loaded horn.

Richard H. Ranger (Rangertone, Inc.): Isn't your premise that the intensity is the most important factor in initial stereophonic work, directly limited to frequencies from 1000 cycles up, because the human head itself serves as a cross-over point where below 1,000-cycles phase is predominant, and above 1,000-cycles intensity is the dominant factor for spatial emphasis.

Dr. Frayne: Somewhere in that neighborhood.

Plotting Device for the Animation Stand

By C. E. BEACHELL

A time-saving device to plot movement over stationary artwork on the animation stand, assuring smooth movement in acceleration and deceleration, is described. The necessity of working out mathematical coordinates is eliminated. Extremely complicated movements of the stand can be plotted in a short time.

In photographing artwork on the animation stand it is often desirable to move the artwork so that the field of view of the camera appears to move giving the effect of a camera pan. This type of shot is usually made one frame at a time in order to maintain perfect control of movement and field of the finished picture.

The problem is to determine how far and in what direction the artwork should be moved between consecutive frames to ensure smooth acceleration, travel and deceleration of movement in the final footage. These movements must also occur according to a predetermined pattern and must be completed in a predetermined number of frames. This action must be planned and plotted before any attempt is made to shoot the footage, otherwise all of the requirements of the sequence could never be satisfied.

Plotting of these movements can be done mathematically and the curves then traced out on cross-section paper, but this method is very laborious, consumes a great deal of time and does not allow the director very much freedom in his planning of the shot. Complex movements become an absolute headache to the person who has to plot them and very often this person's time could be used to much better advantage. There is also a great probability of error in transferring the coordinate readings from the graph to the transverse and longitudinal verniers of the animation stand. One error means a jerky movement and perhaps a spoiled shot.

At the National Film Board of Canada we have had this problem on a number of productions — notably those dealing with historical scenes — paintings, etchings and other forms of graphic art.

When a film was planned to show the complete works of a famous painter, the problem became colossal and would have consumed months in plotting the pans and zooms by conventional methods.

From a suggestion by Roman Kroiter of our animation department, the problem was solved with a device which could be moved manually on the surface of a piece of clear celluloid placed in registered contact over the artwork concerned. This device or plotter leaves a trail of marks embossed into the surface of the celluloid (referred to as cell in animation).

The original model of the plotter had a flat, stainless-steel and highly polished bottom surface which came in contact with the cell. This bottom surface had a hole in the center through which a pin protruded and retracted when an alternating voltage was fed to an electromagnetic driving mechanism. Some difficulty was encountered with this arrangement in that the flat surface showed a tendency to stick to the cell, thus destroying smoothness of movement. This was partially overcome by lubrication with powdered borax, but still was not entirely satisfactory. Recently, the plotter was modified to provide three-point suspension on free-swinging, ball-bearing casters (Fig. 1). This permits absolutely free movement in any direction with no tendency to stick and lubrication of the surface of the cell is not necessary (Fig. 2). This design also presents a clear view of the artwork at the point where the pin marks the cell. The pin is mounted on the end of a soft iron armature which is free to move only longitudinally. Polarized magnetism is induced from permanent magnets into the armature, which is located in the field of a coil fed by alternating voltage. As the field of the coil alternates, the armature oscillates longitudinally according to the amplitude and frequency of the driving voltage.

A sine wave was found to be the most satisfactory. Square waves and pulses were tried and it was found that, due to resonance of the armature mass and suspension, the armature motion did not faithfully follow the driving voltage amplitudes throughout the desired band of frequencies and tended to produce a trace in which odd marks would be skipped.

A sine wave protrudes the pin for a measurable amount of time and, as the movement of the plotter is accelerated, produces progressively longer dashes. The length of these dashes may be used as an index to introduce the correct amount of motion blur to reduce jitter on fast movements.

We have found that when there are more than 80 marks in a plotted path

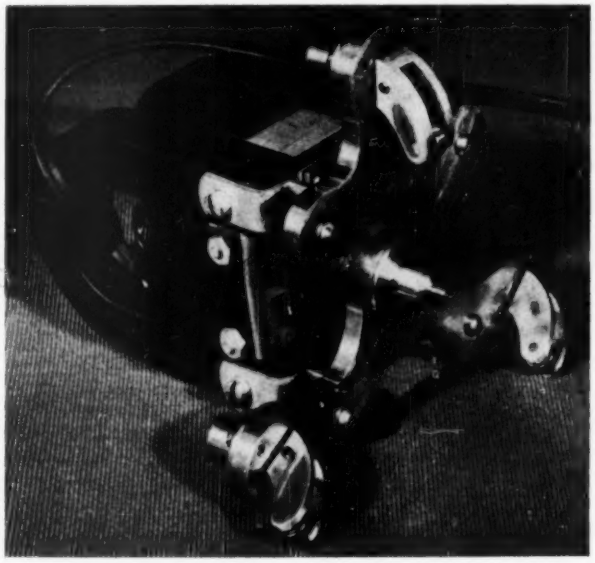


Fig. 1. Modified plotter with three-point suspension on free-swinging, ball-bearing casters.

Presented on May 6, 1954, at the Society's Convention at Washington, D.C., by C. E. Beachell, National Film Board of Canada, John St., Ottawa, Ont., Canada.
(This paper was first received on April 1, 1954, and in revised form on June 7, 1954.)

Fig. 2. The plotter permits free movement in any direction with no tendency to stick.

contained in the field, jitter will be imperceptible. If there are less than 80 frames in a movement across the field covered by the camera on the artwork, some type of anti-jitter device should be used. We are at present working on an automatic motion blur device which shows promise of eliminating this problem.

At present we are using an audio signal generator driving a 25-w power amplifier to provide the necessary alternating voltage. The depth of the embossed marks is set by the amplifier volume control. The useful range of frequencies was found to be from 12 to 72 cycles/sec.

With the oscillator set at 24 cycles/sec, the trail of embossed marks left on the surface of the cell as a result of any movement of the plotter — regardless of complexity — exactly locates the center cross lines of each successive frame in the sequence of movement. Under these conditions, the apparent movement of the camera in the finished and projected film will be exactly the same as the plotter movement.

For exaggerated speeds of movement, the oscillator may be set at a low frequency, say 12 cycles/sec, which is half speed — then the apparent movement of the camera will be twice that of the plotter. Very slow movements may be plotted by raising the oscillator frequency. Generally smoother movements are achieved with higher frequencies as the plotter, being manually operated, can be moved faster, thus ensuring smoother accelerations and decelerations.

Shots may be timed to fit a musical score by moving the plotter to the rhythm of the actual music or to the beat of a metronome. The tempo of the rhythm may be multiplied or divided as necessary to comply with the frequency driving the plotter, using 24 cycles/sec as an operating base number. The embossed marks are made clearly visible by drawing a line over the marks with a black grease pencil and then wiping the line off the cell. This fills the marks with black opaque material (Fig. 3).

The cell carrying the plotted line of marks is then placed in registration on a table surface which is part of the bed of the animation stand. A low-power microscope, carried on an arm rigidly fastened to the moving table which carries the artwork, is located over the plotted cell. This panning table was especially designed by our engineering department for use with this type of work (Fig. 4). There is absolutely no backlash in the controls of the table and the table will not change its alignment when a control is reversed. When the artwork and plotted cell are in position, the table is then moved so as to center the cross lines in the microscope over the beginning of the first mark in the plot and the first frame is shot. The table is then moved so that the cross lines fall on the beginning of the second mark and the second frame is shot and so on, to the end of the sequence. The microscope field may be projected on to a convenient screen thus giving an enlargement of the cross lines and plotter marks. This makes the operation of the stand easier, faster and more accurate.

Zooms may be plotted with this device by moving the plotter over a strip of film whose length is determined by the maximum movement required of the camera.

Fig. 3. Celluloid overlay showing embossed marks outlined by black grease pencil.

The plotter may be accelerated and decelerated at the points desired in the sequence. The zoom plot is mounted along the vertical path of the camera and movement is determined by the marks on the strip of film in the same manner as for pan movements.

There is no limit to the complexities of movement on the animation stand when using this plotter. Movements may be plotted in seconds. When the plotted cell is still in place over the artwork, the field may be checked quickly with another piece of cell having a frame the size of the planned field and cross lines in the center inscribed on it. This frame may be moved over the plotted path and the composition of each frame checked throughout the sequence. See Fig. 5.

All this may be done in minutes instead of hours as required by the mathematical approach. If the first two or three plots are unsatisfactory, the plot may be repeated until a completely satisfactory sequence is obtained with comparatively little expenditure of time and material.

Thanks are due to Roman Kroiter, who suggested the possibility of a device of this nature, Colin Low and Al Johnstone of the National Film Board staff for their suggestions and assistance on this project.

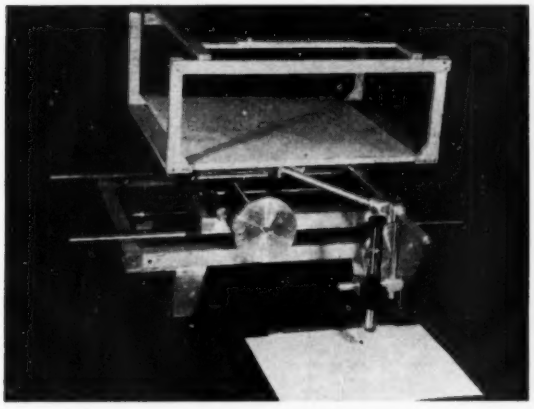


Fig. 4. Panning table with microscope attached.

Fig. 5. A sequence of movements on additional cell.

Electronic Shutter in Television Film Pickup

By F. CECIL GRACE

In storage-type television film pickup systems, usually either the light source is pulsed or else a mechanical shutter is used on the projector. This paper describes a third method, wherein the film is projected continuously, even during pulldown, on the photocathode of an image-orthicon tube. The image section of the tube, however, is keyed electronically so that it operates only during vertical blanking. Simple apparatus for use with studio cameras is described.

THERE HAS long been a need for a low-cost system for television film pickup which would permit the use of standard projectors, not especially designed for television applications, along with a standard studio television camera. In the past this has not been practicable because major modifications would be needed to convert the shutter system of a standard projector to produce 60 light pulses a second, and because there is not room in the projector for the bulky d-c polarized synchronous motor.

Through the use of the equipment to be described, however, the only modification needed to the projector shutter is to remove it entirely (an easy operation), and let the Electronic Shutter take over its function. Furthermore, a d-c polarized motor is not needed. A nonpolarized synchronous motor is scarcely larger than the nonsynchronous motor normally used in projectors, and some projectors may be ordered from the factory with one fitted.

In addition to its low cost, this system offers the advantage of practically no obsolescence to the broadcaster planning later to purchase a film scanner, since he can use the camera in the studio and the projector in the film room (after replacing its shutter). Its synchronous motor will permit accurate timing of films.

This equipment is based on a British development, but has been greatly simplified, so that it uses only two tubes. It takes advantage of the fact that, in an image-orthicon tube, storage takes place on the target, and any image stored there may be read off by the scanning beam even though the image section is not functioning at the time. The Electronic Shutter keys the image section on and off by keying the voltage to the photocathode. During vertical blanking the image section operates, and the image, in the form of an electrical charge pattern, is transferred to the target. Then, while the target is being scanned, the image section is inoperative. If the projector pulldown occurs only during the scan period, when the tube is effectively blind, no travel ghost will appear in the television picture, even though it exists on the pickup tube photocathode.

Figure 1 shows the complete circuit diagram of the shutter. The bottom half of the figure is the variable source of negative voltage for the photocathode of the image orthicon. It also furnishes the power needed by the tubes in the unit. The power transformer is tapped as shown, and places 120 volts across a small variable autotransformer. It can easily be seen from the diagram that, as the autotransformer brush is moved from one limit to the other, the voltage at the input to the rectifier varies from approximately 120 to 240 v. The rectifier is a selenium voltage doubler, and delivers approximately 300 to 575 v, negative to ground, after filtering.

The 6AV5 is a keying tube which passes this voltage to the image-orthicon tube at the proper time. When this tube is at zero bias, there will be about 25-v drop across it. Thus it will be quite easy, by adjusting the autotransformer, to vary the photocathode voltage over the normal focusing range of 300 to 500 v, and even to go to the 550 v required by a few tubes. On the other hand when the 6AV5 is cut off, the photocathode voltage goes to zero.

The 6AV5 is driven by amplified vertical drive pulses, from beyond cutoff to the grid conduction point. The 3.9-megohm resistor, returning to a point more negative than the cathode, serves merely to prevent excessive current flow in the event drive fails.

The 6C4 amplifier tube operates also from the source of variable voltage. This is desirable because, as the 6AV5 plate and screen voltages are increased, its cutoff voltage increases also. At the same time, the 6C4 receives more plate voltage so that it will always cut the 6AV5 off between pulses.

The 6C4 grid is transformer-coupled to the incoming drive. Modern audio transformers will pass a vertical drive pulse with little distortion, and this little is removed by clipping. This arrangement has two advantages. First, without it, whenever the focus voltage was changed, there would be an instantaneous change in grid-to-cathode voltage of the 6C4, and the unit would be inoperative until the coupling capacitor had assumed its new charge. Second, without it there would be a tendency to motorboat, due to the power supply impedance.

By removing a jumper, an electrolytic capacitor may be placed in series with the transformer primary. This should be done if there is d-c on the drive.

In simplifying the equipment to this extent, it has been necessary to accept two minor disadvantages. First, since the power supply is not regulated, it is always necessary to operate the unit from a line regulator. Since some types of regulators flatten the a-c waveform, and result in a reduced voltage from capacitor input filter systems, taps are provided on the power transformer and the variable transformer to provide a 10% boost. Secondly, the photocathode

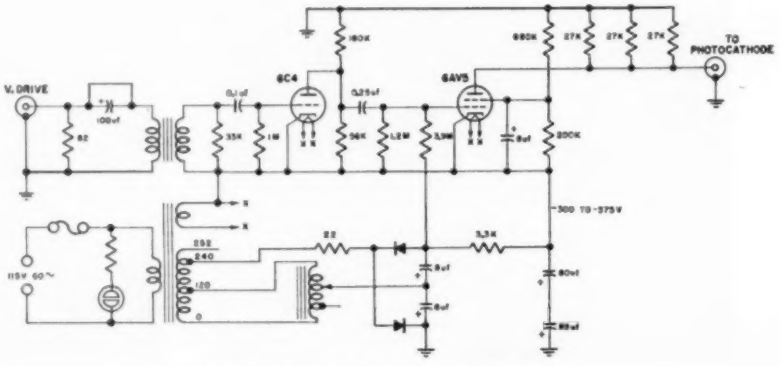


Fig. 1. Electronic Shutter circuit diagram.

Presented on May 7, 1954, at the Society's Convention at Washington, D.C., by F. Cecil Grace, Communication Products Div., Allen B. Du Mont Laboratories, Inc., 1500 Main Ave., Clifton, N.J.
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pulse voltage will have the same duration as the incoming vertical drive. The Radio-Electronics-Television Mfrs. Assn. specifications state that this shall be between one-half and one times vertical blanking width. In order, however, to have the image section of the image orthicon operate for as long a time as possible, the station should adjust its synchronizing generator to produce a vertical drive pulse at the longer limit of this specification.

Figure 2 shows the Electronic Shutter with the cover in place, and Fig. 3 shows the chassis with the bottom plate removed. The variable transformer fits completely under the chassis as shown.

Stations using this equipment usually have a translucent screen mounted in the wall between the control room and the studio. Two projectors are located in the control room, and an optical multiplexer permits either of them to project onto this screen. The multiplexer also turns the image around so that it will be correct as seen from the studio side. The camera, in the studio, is modified by adding a video patch jack, for connection to the Shutter, and a double throw switch. This switch permits connecting the image-orthicon photocathode either to the patch jack, and thence to the Shutter, or back to the circuit originally provided in the camera. Then if it is desired to use the camera for normal studio use, it is only necessary to throw the switch. If the camera is to be dollied away from its position near the screen, the plug may be pulled out.

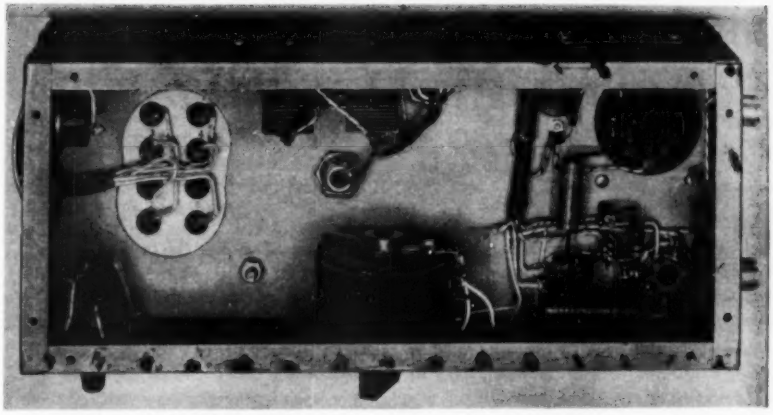

Fig. 3. Underside of Electronic Shutter with bottom plate removed.

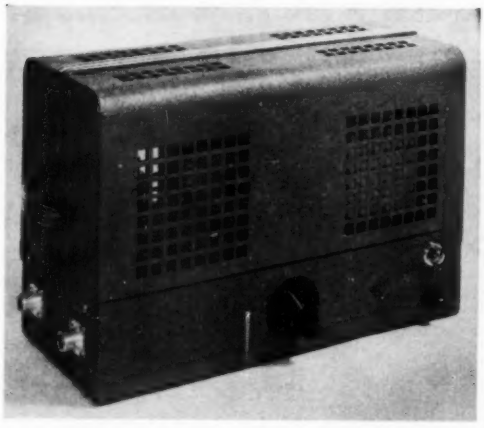

Fig. 2. Electronic Shutter, front view.

Setting up the camera with this equipment is extremely simple. First, the switch is thrown to normal operation and the camera is set up in the usual manner, focusing electrically and optically on a scene in the studio. Then switch to the Electronic Shutter. Without touching any of the camera controls except the iris — more light may be needed because of the low pulse duty cycle — bring the camera back into focus by adjusting the variable transformer in the Shutter. Then project a film on the screen and adjust the camera to frame it correctly. Adjust the synchronizing generator phasing, or projector phasing, if adjustable, so that the travel ghost disappears. Note that if the projector phasing is not adjustable, and two projectors are used, both must be assembled mechanically so that the same synchronous generator phasing is correct for both of them.

If, during operation, the image focus needs slight readjustment, this may be effected at the camera control console by varying the image (or photocathode) focus control. This may seem surprising, since the photocathode is no longer connected to this control. However, the control also affects the G6 voltage, and changing the G6 voltage alone will refocus the tube if it is out to only a slight extent.

Thus, with this equipment, it may be seen that any station having an image-orthicon camera can broadcast film at very little cost for additional equipment, without impairing normal studio use of the camera. This equipment has been the sole film system of several stations which plan later to purchase film scanners, and it may be retained as an emergency system in case other equipment fails.

Subject-Lighting Contrast for Color Photographic Films in Color Television

By F. T. PERCY
and T. GENTRY VEAL

Set-lighting in making motion pictures for color television is described. It was found that optimum television picture quality was obtained when the subject-lighting contrast was reduced to correspond more nearly with the range of brightness which can be reproduced over a color-television system.

EVER SINCE the first photograph was made over a century ago, photographers have been concerned by the fact that many of the scenes they tried to reproduce had a brightness range (or, in modern terminology, a luminance range) much greater than the photographic process was capable of handling. Luminance ranges in nature may exceed 300 to 1, while most photographic transparency processes will only reproduce satisfactorily a range of approximately 100 to 1. The common "soot and whitewash" effect of most amateur snapshot prints shows what happens when the luminance range of the process is greatly exceeded by the range in the scene; the highlights are washed out and the shadows are barren of detail; even the reproduction of the middletones is unsatisfactory. A similar situation exists when photographic films having a luminance range of 100 to 1 are used as a source of material for monochrome television, which will not reproduce a luminance range greater than about 30 to 1. When motion-picture films are projected onto a television film camera for subsequent transmission, and these films have a greater luminance range than the television system will accept, it results in (a) excessive compression effects that render shadow detail invisible and (b) a general degradation of picture quality. The compression effects become acute when the problem of shading, signal storage and signal-to-noise ratios are taken into consideration in the operation of a television film camera.

In the artificially lighted scenes that are commonly used for television, the photographer controls the luminance range of the scene by the intensity and posiiton of his lamps. Here he must depart from standard motion-picture technique and limit the luminance range recorded on the motion-picture film by proper subject-lighting contrast. Subject contrast might be considered as a property of the scene before the camera lens. However, it should be remembered that the term subject-lighting contrast should not be confused with subject contrast or subject-brightness range. The subject contrast or subject-brightness range is usually much higher than the subject-lighting contrast, since it takes into account the difference in reflectance of the various elements of the scene.

Figure 1 shows a subject illuminated with two lamps. The first lamp, known as the key-light, sets the general level of illuminance and the distribution of shad-

Fig. 1. Subject-lighting contrast 4 to 1.

Fig. 2. Subject-lighting contrast 2 to 1.

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ing over the subject. The second lamp, known as the fill-light, is placed to fill in the shadows suitably and to soften the effect. In this figure, the illuminance on the subject from the key-light is four times the luminance from the fill-light, or, in photographic parlance, the subject-lighting contrast is 4 to 1. This is common practice in making ordinary motion pictures for theaters. In Fig. 2 is the same subject when the subject-lighting contrast has been reduced to 2 to 1. This picture could be reproduced by monochrome television satisfactorily, and it is good practice to run the contrast to 2 to 1 for this purpose. In both pictures, supplementary illumination has been added to the background.

At first thought, there seems to be a wide discrepancy between a subject-lighting contrast of 2 to 1 and the luminance range of 30 to 1 that a television system will transmit. However, this discrepancy is only apparent, as can be seen in Fig. 3. In the figure, the man's shirt reflects 110 times as much light as his suit, when both are illuminated by the same amount of light. In the present instance, the subject-lighting contrast is 4 to 1; the shirt is in the most brightly illuminated region and part of his suit is in the deepest shadow. The luminance range of the entire scene is not 4 to 1 or even 10 to 1, but 110 to 1, a range too great for any commercial television system to reproduce. To correct this scene for television transmission would require either limitation of minimum reflectances by the choice of wearing apparel or supplementary lighting of regions of low reflectance.

Fig. 3. Subject-lighting contrast 4 to 1.

Fig. 4. Subject lighting with key light only.

The effect of varying the subject-lighting contrast can be clearly seen from from the next three figures. A key-light alone was used for Fig. 4, so the only light in the shadows was the light reflected from the walls of the room. A fill-light has been added for Fig. 5 to lower the subject-lighting contrast to 4 to 1, as in black-and-white motion-picture photography for theaters. Nevertheless, the luminance range is still too great to be reproduced satisfactorily even in monochrome television. Figure 6 shows the effect when the subject-lighting contrast has been lowered to 2 to 1. The key-light was at an angle of about 45° from the camera and at a distance from the subject equal to the camera distance; the fill-light was near the camera. For Fig. 6, no supplementary illumination was used on the background, as was done for Figs. 4 and 5, which explains why the impression of depth is less marked in Fig 6.

The advent of color television has restricted the permissible luminance range still further because the maintenance of proper color balance requires a fixed relationship as well as a degree of similarity between the transfer characteristics of the three color channels. The only control common to all three channels is the iris diaphragm in the light path of the three light-sensitive receptors. By holding the luminance range on the motion-picture film to a range the color-television system will accept, the control operator is able to operate the system at an optimum level to provide the best picture quality obtainable. The transfer characteristics of the three color channels in a television system must be adjusted to give proper color balance or gray scale throughout the luminance range. It is not practical to correct for neutral balance with luminance changes.

It is normal monochrome practice to allow the image orthicon and iconoscope to operate in such a manner that the scene highlights are allowed to extend beyond the knee of the transfer characteristic curve. Color cameras, whether used for live pickup or film pickup, should be operated with the highlights certainly not beyond the knee of the transfer characteristic curve. If they are operated beyond the knee, a loss of color balance will result. This is also true if the range of photomultipliers is exceeded when used in flying-spot scanners, although the range is considerably greater than with storage tubes. This factor alone indicates the desirability of holding highlight brightness and overall brightness range well within the brightness limitations of the color-television system. The effect of varying the subject-lighting contrast in color television can be seen from Figs. 7–9. In Fig. 7, the lighting contrast is 3 to 1.

This reproduction is fair, but still the contrast is somewhat high. Figure 8 shows the same subject when the lighting contrast is 2 to 1. We have made many tests, and our conclusions are that, in general, this contrast is the most suitable for reproduction by color television. In Fig. 9, an attempt has been made to reduce the lighting contrast to 1 to 1. It is difficult to obtain such a low contrast when several lamps are used without resorting to diffusing materials on the lamps, and despite the care taken in lighting this scene, the lighting contrast probably was not exactly 1 to 1. Even so, the scene is not unpleasant or abnormally flat.

But there is another feature of the scene that is important in securing a pleasing and lifelike representation. That is the tone of the background, as has been pointed out in passing. In Fig. 10, the background is illuminated only by lights used to illuminate the subject herself. The scene appears to have little depth, and the subject looks like a paper cut-out pasted against the background. Figure 11 is the same scene but with adequate background lighting, and one now realizes that the subject is standing about six feet in front of the background. Figures 12, 13 and 14 show a typical commercial subject under the same conditions. No extra lighting was used on the background in Fig. 12. Additional back-lighting was used on Fig. 13 to create depth. Figure 14 certainly gives a stronger sense of nearness to the observer. In all of these scenes, the subject-lighting contrast was 2 to 1, in accordance with our recommendations.

In conclusion, we recommend that, when color films are used as a source of material to be transmitted in color by a television system, the subject-lighting contrast be of the order of 2 to 1, unless the conditions are unusual. Furthermore, we recommend that the background be lighted adequately to give a sense of depth to the scene. These recommendations are not dependent on the type of photographic material or on the type of television film camera used. This also includes flying-spot scanners. Masking techniques have been described recently for improving the purity of the colors on the television screen, but there is no reason to believe that the adoption of such techniques will require the alteration of our recommendations.

Fig. 5. Subject-lighting contrast 4 to 1.

Fig. 6. Subject-lighting contrast 2 to 1.

Fig. 7. Subject-lighting contrast 3 to 1.

Fig. 8. Subject-lighting contrast 2 to 1.

Fig. 9. Subject-lighting contrast 1 to 1.

Fig. 10. Subject-lighting contrast 2 to 1, no background illumination.

Fig. 11. Subject-lighting contrast 2 to 1, with background illumination.

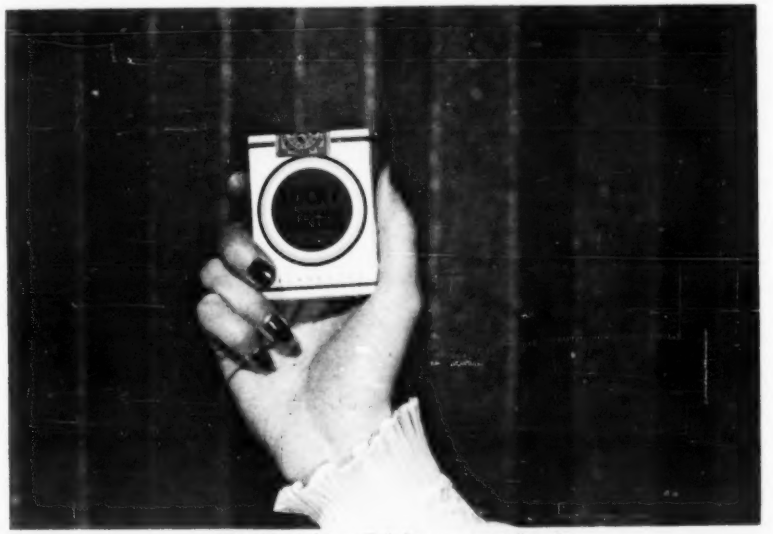

Fig. 12. Subject-lighting contrast 2 to 1.

Fig. 13. Subject-lighting contrast 2 to 1, with back light.

Fig. 14. Subject-lighting contrast 2 to 1, with back light and additional background illumination.

Navy Development Program for a Brighter Projector Light Source

By PHILIP M. COWETT

In 1946 the Navy Bureau of Ships realized that a new light source would have to be found and adapted to the Joint Army-Navy type 16mm projectors, then under the initial phases of development, if the shipboard and overseas 35mm replacement program was to be completely acceptable to all equipment users. The xenon lamp appears to provide the desired answer.

PRIOR to World War II large Navy vessels were equipped with motion-picture projection booths and 35mm arc projection equipment for the showing of motion pictures either topside, on the weather deck or in the hangar area of aircraft carriers as applicable.

The advent of war forced the topside movies "underground," or below decks, and the necessary replacement of arc-type 35mm equipment with semiportable 35mm incandescent projectors, thereby enabling individual shows to be brought directly to shipboard personnel. The booths were taken over by other types of equipments *not* entertaining to the enemy.

During this same period, 16mm commercial projectors, purchased as a part of the Navy's training film program, were also used, to show to small groups, the 16mm entertainment courtesy prints very graciously supplied by the motion-picture industry. Here the high portability and flexibility of use of the 16mm equipment and films were demonstrated.

After the war, 35mm performance was still desired, but 16mm portability, low cost, and ease of operation were needed. So, the Fleet, itself, said: "Give us 16mm equipment and films with performance as good as our pre-war 35mm." This of course had the advantage of making projectors and films available to a larger number of smaller vessels. But, with projection booths either gone or reduced in size, there was no room for arc lamps. It was, therefore, not long before this phrase was deleted from the original JAN-P-49 specification: "The projector shall be so designed that the incandescent lamphouse may be removed and replaced by an arc lamphouse without any mechanical modification of the projector."

To meet the requirements of the fleet and field forces, the Armed Forces sponsored the development of a JAN (Joint Army-Navy) 16mm projector capable of superior performance. However, despite booth restrictions, the Navy realized that more light was needed in some ships than the presently available 525 lm from JAN projectors. The Navy's equipment, projection conditions and exhibition requirements have been described in earlier papers in the *Journal* for March 1952 and July 1953.

So, a search was begun for a new light source which would fit into the JAN projector without major equipment redesign. The Navy has realized this need for some years and investigated small, high output, light sources from various countries. The problem of obtaining more light from Navy projectors was also informally discussed with representatives of various lamp manufacturers. At that time no one appeared to be ready to undertake to further develop and adapt new types of light sources to our projectors.

During 1951, the mercury-xenon lamp, came to our attention. It was being adapted to the Navy's 12-in. signalling searchlight by the Hanovia Chemical and Manufacturing Company of Newark, N.J. Discussions with this company showed the possibility of adapting a xenon lamp to the JAN projector. The mercury-xenon lamp was rejected because of improper color characteristics. A JAN projector was loaned to this company for running routine tests using experimental 1,000-w xenon lamps. Even under crude conditions, with the lamp improperly focused and without proper condenser lenses, the projector still delivered 1200 lm of light to the screen through a 2-in. $f/1.6$ lens.

At this point the Bureau of Ships again unofficially tried to interest several manufacturers in the Navy's light problems without success.

It was not until February 25, 1953, that the DeVry Corporation of Chicago, Ill., was awarded Contract NObs 61644 which contained the following requirements:

"(a) Study and investigate Hanovia (or equal) xenon and krypton lamps (and similar lamps if deemed feasible) with a view toward determining which light source offers the greatest promise of successful and practical application to Navy Type AQ-2(1) 16mm sound motion-picture projection equipment.

"Adapt the above light sources for use as a part of Type AQ-2(1) equipment, making the fewest possible changes to still permit achievement of the required objective, which is to be able to place more light on a motion picture screen in Navy open air theatres or topside aboard ship, since present light output is inadequate for most large screen usages.

"It is desired to obtain safely and with no structural or mechanical changes to the AQ-2(1) equipment, at least 2,000 lumens of light at the screen when using a 2 inch, $f/1.6$ lens and when tested in accordance with the requirements of Military Specification MIL-P-49A-(Ships).

"The light source chosen as the most practical, considering light output requirements, safety, ease of operation, cost, life, availability, etc., should, if possible, be capable of operating within the voltage and frequency tolerances specified in referenced specification MIL-P-49A(Ships), without the use of external starters or converters, etc. If starters or converters are required, they should be designed to be compact, easily attached to projector mounting base, type IC/QBA, or to the deck or bulkhead as necessary.

"(b) The most promising light source shall be incorporated as a part of the modified AQ-2(1) 16mm sound motion picture projection equipment and furnished as a working model. The entire equipment as modified with the new light source, or sources, shall conform to the requirement of specification MIL-P-49A(Ships). This refers to ruggedness, workmanship, performance (such as uniformity of light output), electrical characteristics, and material requirements."

A telegram received by the Bureau of Ships from the DeVry Corporation on December 8, 1953, states: "We have achieved 2,000 lumens target objective set forth in light source development project." The manner in which the objective was reached will be discussed in subsequent papers by representatives of the lamp and projector manufacturers.

Recent checks by the Navy Motion Picture Service, Brooklyn, N.Y., indicate that the new light source is highly suitable for use with current types of color prints as well as black-and-white.

Laboratory tests of the new light source reveal performance in excess of the following:

Light output: 2,000 lm; and

Uniformity of screen illumination: Average illumination at four corners, 77% of the illumination at the center of the screen; low corner illumination, 75% of the illumination at the screen center.

In closing, I should like to state that the success of this new light source, as attached to projectors of the Armed Forces, is to a very great extent due to the close cooperation between a lamp manufacturer, who had faith in his lamp, a projector manufacturer, who had faith in his projector, and the Navy Department, which has faith in American ingenuity and industrial ability.

Presented on May 5, 1954, at the Society's Convention at Washington, D.C., by Philip M. Cowett, Dept. of the Navy, Bureau of Ships, Washington 25, D.C.
(This paper was first received on May 5, 1954, and in final form July 15, 1954.)

High-Brightness Xenon Compact Arc Lamp

By WILLIAM T. ANDERSON, Jr.

Xenon compact arc lamps have been developed which have high brightnesses, spectral-energy distributions in the visible spectrum resembling closely that of sunlight, and color temperatures of 5200 to 6000 K. A 1000-w lamp for a-c operation is described and its characteristics enumerated. When these lamps are operated on suitable a-c electrical circuits, they may be used very satisfactorily in portable equipment for projection of 16mm film by CinemaScope and 3-D optical systems.

THE LIGHT-EMISSIVE properties of gases and metal vapors have been investigated extensively by research laboratories in many parts of the world during the past two decades. Their behavior in the electric arc is interesting in particular because this is the form of electric gas discharge which may produce high brightness. High brightness is a very desirable attribute for a light source employed with an optical system. The results of some of these investigations have been summarized by W. Thouret[1] and J. N. Aldington.[2]

When a gas or a metal vapor is used as the conductive medium in an electric arc, radiation is emitted mostly in a line spectrum. A color unbalance results. Thus, cerium is too blue. Mercury and cadmium are too green. Sodium is too yellow. Neon is too orange-red. They differ in this respect from sunlight or the incandescent lamp which produces a spectral continuum. A spectral continuum is desirable for satisfactory color rendition.

Gases and metal vapors maintained at very high vapor pressures and heated to very high temperatures in the arc produce a continuum in addition to the line spectrum characteristic of the specific substance. Thus, mercury vapor maintained at a vapor pressure in excess of 200 atm emits in the electric arc an appreciable continuum. It is not possible at this time to use such pressures in practical lamps, and even if it were, the additional band emission would result in spectral unbalance.

Xenon gas has two unique properties which have recommended it as a potential source for a continuum in the visible spectrum. Its line spectrum is located in the infrared and is hence invisible to the eye. Such lines as do exist in the visible spectrum are insignificant in energy content. Xenon is the heaviest of the gases excepting radon, the gaseous emanation from radium. Xenon has a low specific heat which enables it to be quickly heated to high temperatures so that it can radiate a continuum.

Paul Schulz[3] in Germany appears to have been the first to make a xenon compact arc lamp and to describe some of its properties. The writer heard about the Schulz lamp while serving with the U.S. Navy during World War II, and, upon return to civilian status, began an experimental exploration of xenon gas and its reactions in an electric arc. The results of the preliminary researches were reported to the Washington meeting of the Optical Society of America in March 1951.[4]

The investigation has continued in the direction of the development of xenon compact arc lamps of high brightness, dependable steadiness, and performance satisfactory for optical and projection applications. One type of lamp developed has been employed by E. W. D'Arcy and his associates in the De Vry Corp., in conjunction with their circuits and controls to achieve projection of 16mm colored films by 3-D and CinemaScope optical systems at brightnesses and with color rendition not previously attainable in portable equipment. Some of the characteristics of this xenon compact arc lamp will be described.

Description of Xenon Compact Arc Lamp

Fundamentally the xenon compact arc lamp is an electric arc in a confined xenon gas medium between two closely spaced electrodes. Electrically it has many of the characteristics of similar vapor arcs, such as mercury.[5] It is in its radiation characteristics that it differs greatly from the other arcs.

Figure 1 shows a 1000-w xenon compact arc lamp. The lamp must be used vertically as shown. The lamp proper is substantially spherical to provide strength, as the gas pressure increases to more than 20 atm during operation. The two appendages contain the vacuum seals and current lead-ins, and support the electrodes, to the ends of which the arc attaches itself during operation of the lamp.

The arc is designed for high-temperature operation in excess of 6000 K, for a sunlike temperature is required to provide the desired continuum in the visible spectrum.

The envelope of the lamp is made of excellent-quality, fused quartz which can be operated at the required measured temperature of 1200 K. Fused quartz is the only known transparent material which can be employed at such high temperatures.

Since the gas pressures in the lamp are always in excess of atmospheric pressure, it is a reasonable precaution to protect the eyes and exposed parts of the body. During handling, the lamp should be provided with a temporary cover.

The characteristics of the xenon compact arc lamp are given in Table I.

The light from the arc is not uniform in brightness transversely or axially. This results from variations in xenon density and temperature in the arc.

When viewed, the arc appears to be wedge shaped with the thin end of the wedge attached to the lower electrode. The central section of the wedge has the most uniform brightness and, although it is not the brightest part of the arc, is preferred for projection and optical applications. A suitable reflector can correct for the wedge shape and also can enhance the brightness.

The light output from the lamp varies as the square of the arc wattage. Thus, operation of the lamp at 800-w instead of at the rated 1000-w input will reduce the light output to approximately 65%.

Fig. 1. 1000-w xenon compact arc lamp.

Presented on May 5, 1954 at the Society's Convention at Washington, D.C., by W. T. Anderson, Jr., Research Laboratory, Hanovia Chemical and Mfg. Co., Newark 5, N.J.
(This paper was first received on February 18, 1954, and in revised form April 4, 1954.)

Table I. Characteristics of the Hanovia 1000-W Xenon Compact Arc Lamp, 60-Cycle, A-C

	Lamp No. 1	2	3
Supply volts	115	115	115
Lamp watts (excluding controls)	1000	1000	1000
Lamp volts*	35	33.5	32.5
Lamp current (amp)*	31	34.2	35
Arc-length (mm)	7.2	6.8	6.6
Initial lumens (total light)†	43,500	45,000	47,000
Maximum brightness (c/sq cm)	50,200	52,150	53,300
Average axial brightness (c/sq cm)	17,500	17,900	18,300
Color temperature, K			
Total light†	5,170	5,250	5,280
Arc only	6,000	6,000	6,000
Intensity of light at cold start in per cent of full intensity	65	68	72
Rated life‡	not rated		
Physical dimensions			
Overall length, in.	7.420	7.385	7.372
Outside diameter bulb, in.	1.630	1.618	1.624
Lamp operating position	vertical		

* Resistive ballast. Electrical characteristics and waveshape depend on control design.
† Includes appreciable radiations from incandescent quartz and electrodes.
‡ Insufficient data for rating purposes. A few test lamps have operated in excess of 300 hr.

The Visible Light From the Arc of the Xenon Compact Arc Lamp

The visible spectral-energy distribution of the xenon arc comprises an intense continuum upon which are superimposed a number of scattered, relatively weak spectral lines of ionized xenon gas. The energy in watts per 100-A strip radiated by the arc only of the 1000-w lamp is indicated in Fig. 2.

It will be observed that in the visible spectrum approximately 85% of the energy radiated originates from the continuum and only about 15% from the line spectrum. For a mercury lamp these percentages would be just reversed.

Since more than one-half of the energy of the line spectrum of xenon lies in the violet where the eye response is poor, the effective line spectrum contributes only about 8% to the total visibly weighed light and therefore modifies the continuum to a slight extent only. Even when the line spectral energy in the violet is included, an excellent match with sunlight is obtained. Table II provides this comparison.

Table II. Sunlight Compared With Light From Xenon Compact Arc Lamp in Per Cent of Visible Energy.

Spectral range, A	Color aspect	Sunlight*	Xenon lamp†
4000–4400	violet	9.2	14.5
4400–4900	blue	16.4	17.5
4900–5600	green	22.7	19.0
5600–5900	yellow	14.0	13.0
5900–6200	orange	10.0	8.5
6200–7000	red	27.7	27.5
		100.0	100.0

* Computed from "Radiation Parameters," *Illuminating Eng., 36:* 932, Table 1, 1941.
† Arc only.

By virtue of its continuum, the xenon compact arc lamp possesses one characteristic which is very important for the De Vry Portable Projector, namely, that the a-c xenon lamp is extinguished each time that the electrical cycle reverses. The lamp is extinguished 120 times per second when operated on 60-cycle alternating current.

Xenon lamps differ radically in this respect from other arc lamps. The factor that enables a xenon compact arc lamp to produce an intense continuum free from interference by strong emission lines is also responsible for this behavior on 60-cycle alternating current. The intense line spectrum of xenon lies in the infrared where it is invisible to the eye. It is the same ionization which produces the line spectrum that enables the arc to be re-established when again the electrical supply voltage increases after a change of cycle. An ionization carry-over is required for the maintenance of an arc. Xenon's ionization carry-over does not produce observable light.

The continuum of xenon does not produce a carry-over during the cycle change. Gases cool very rapidly. The continuum shifts back and forth into the infrared. There is no discernible visible light from the arc when the current and voltage approach zero.

The xenon continuum is not confined to the visible spectrum. It extends through the ultraviolet to the limit of transmission for the fused-quartz envelope. It resembles in many respects the sunlight ultraviolet as recorded from high-flying rockets.

The infrared line spectrum is mostly concentrated between 0.8 and 1.0 μ. The lamp is an especially intense source for these radiations.

It can be appreciated that this new high-brightness xenon compact arc lamp should fill a gap in the range of artificial light sources where a continuum and its resulting excellent color rendition are desired.

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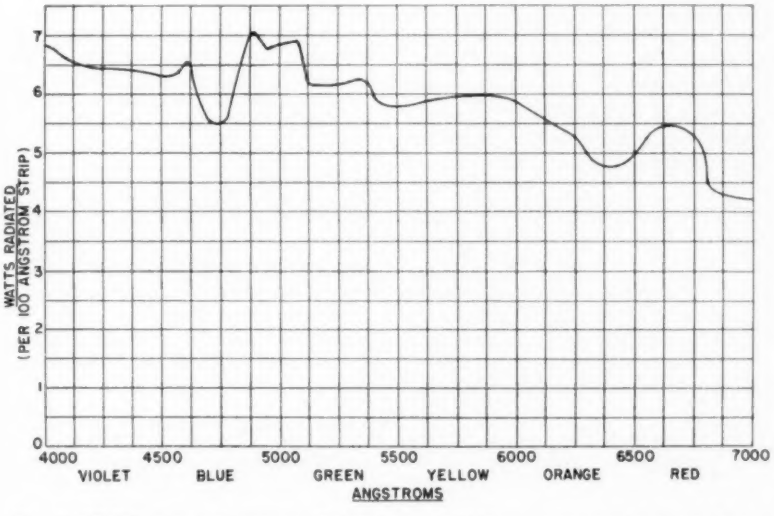


Fig. 2. Visible spectral energy distribution of 1000-w xenon compact arc lamp (arc only — contribution of electrodes and envelope excluded).

Application of the Xenon Arc to the Armed Forces 16mm Projector

By ELLIS W. D'ARCY and ANTON C. SEDA

This paper describes the problems involved, and their solution, in the incorporation of the xenon-arc lamp into the Armed Forces AQ-2(1) 16mm Sound Motion-Picture Projector. Shutterless synchronized pulsed-light operation and the ballast design are explained.

THE NAVY AQ-2(1) 16mm Sound Motion-Picture Projector equipped with the Hanovia arc lamp and its associated power supply is shown in Fig. 1. This is the end result of the Navy-sponsored Armed Forces development described hereafter, and at this time we wish to express our appreciation to the Navy for permission to reproduce the data and illustrations herein, which are taken from the Navy progress reports describing the project's history.

The decision reached by the Armed Forces to substitute 16mm film for 35mm film in their entertainment operation has resulted in complete satisfaction where the screen size has been held to a factor consistent with the light output available from the conventional incandescent type of light source. However, in many cases 16mm equipment has been installed as a direct replacement for 35mm in locations where large screen sizes are accompanied by high ambient light levels falling on the screen, thus causing difficulties with respect to adequate picture brightness and contrast.

Incandescent Light Output

In 1944 a target objective was established by JAN P-49 specification of 375 lm for the 16mm Armed Forces projector when using a 1000-incandescent lamp. The equipment finally developed, however, produced 510 screen lm. This is, however, far from the light output available in 35mm arc equipment which is in excess of 2000 to 3000 lm, approximately four times that available from the most efficient of incandescent-equipped projectors.

Recent standards have been established for 16mm projection of 10 ft-L screen brightness. This value would limit 16mm projection to screen sizes of less than 8 ft for optimum viewing. There are cases, however, where pictures of 18-ft width are attempted. Therefore the drop-off in screen brightness is such that a satisfactory viewer result is impossible and re-emphasizes the need for higher projector light output.

There are a few fundamental considerations which any 16mm light source must meet before its acceptance can be general. These are as follows:

16mm Light Source Color Balance. 35mm projection generally has been with the high-intensity carbon arc as the basic projector light source, which has a color temperature of 5400 K. 35mm prints therefore are color balanced to look their best with this light source. Such a light source is very rich in blue, as compared to the incandescent lamp. However, it is the predominant source now in use, and certainly the end result in the theater is most pleasing.

Now in 16mm film the opposite condition with regard to color balance exists, since the bulk of 16mm products is shown with incandescent-equipped projectors. Hence any substitute for the incandescent lamp having a higher light output must closely match its spectral characteristics.

To ascertain their compatibility, matching Technicolor, Ansco color and Kodachrome prints have been screened by simultaneous projection, using incandescent and the xenon arc at the Navy's Brooklyn Motion-Picture Exchange. The general viewer reaction to the xenon arc was most favorable. The spectral characteristics of this arc vary somewhat, dependent upon its method of use. The end result, therefore, is subject somewhat to optical design. At the conclusion of these tests the decision was reached that the xenon arc was satisfactory for projecting incandescent-balanced prints.

Film Damage. The danger of film damage must be considered as the light projected through the film base is increased. Exact data as to the top limit of illumination which the present film light-absorption methods can transmit have not been precisely established. This depends somewhat on the light source spectral energy distribution.

An estimate of 1600 lm has been the general opinion in the past. A postwar arc projector of better quality has extended this to 2500 lm by means of ingenious heat filters and film cooling.

In view of the preceding, a light-source target objective was established at 2000 lm. This value was exceeded by the xenon arc which has developed 2200 lm with a 950-w electrical input. (See Fig. 2 for the typical screen light distribution.)

Unattended Operation. At this time 16mm film conventionally is delivered on 1600-

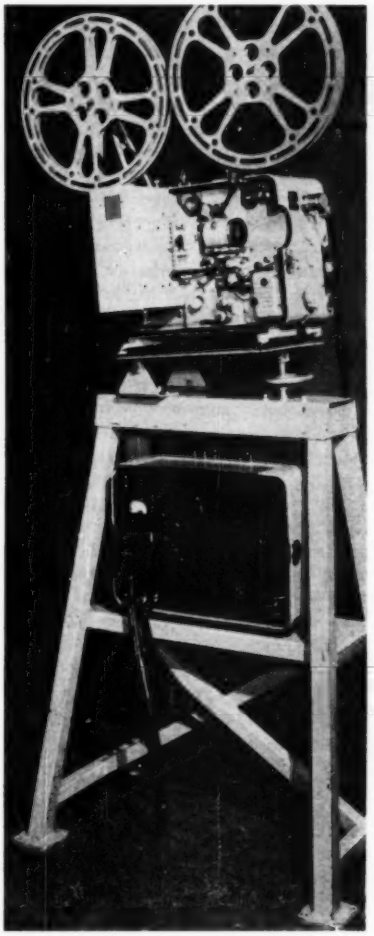


Fig. 1. The Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the Hanovia xenon arc lamp conversion mounted on a standard Navy projector mounting base.

This paper was presented on May 5, 1954, at the Society's Convention at Washington, D.C., by Ellis W. D'Arcy (who read the paper) and Anton C. Seda, both formerly of De Vry Corp. Mr. Seda, recently with Bell & Howell Co., is now associated with the senior author in Ellis W. D'Arcy & Associates, 7045 N. Osceola Ave., Chicago 31. The work described in the paper was carried out by the De Vry Corp. under Navy Contract NObs 61644, and this description has been released for publication by the Department of the Navy, Bureau of Ships, after clearance by the Defense Department.
(This paper was first received on May 5, 1954, and in final form on August 6, 1954.)

Fig. 2. Typical screen light distribution obtained from the Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the Hanovia xenon arc lamp conversion.

ft or 2000-ft reels, with a single projector running time of 55 min. Any light source developed, therefore, would have to take a trim and hold it for 55 min under a very stable operating condition—this in contrast with 35mm practice wherein a 2000-ft reel is standard, having a running time of some 20 min. There are now being manufactured 5000-ft 16mm reels which extend the running time to 2 hr 18 min. In other words, one feature-length film per reel. The xenon arc meets these operational requirements more than adequately, since it can operate in an unattended condition during its life, which is in excess of 300 hr.

Unskilled Operation. Of further concern in the development of a practical type of higher-intensity light source for 16mm projection is the skill of the operator himself. It is a fact that 16mm equipment in the main is operated by a non-professional type of operator, one who does not devote his entire time to the operation of projection equipment. There is, however, quite a degree of skill involved in maintaining a carbon arc in optimum operating condition, and aligning it with the mirror type of reflector, which is gained only through complete concentration on the specialty that it is.

The xenon arc on the other hand, once aligned, requires no further operational attention than does an incandescent lamp during its operational life function.

The Hanovia Xenon-Arc Lamp

The xenon-arc lamp has several unique characteristics which, if enhanced and utilized, permit its incorporation into the Navy AQ-2(1) 16mm Sound Motion-Picture Projector in the most efficient manner.

(1) First, the arc being of high intrinsic brightness, makes the Hanovia xenon-arc lamp optically ideal for projection use. The brightness of the portion of the xenon arc used for projection in the Navy AQ-2(1) projector is higher than that of a carbon arc. Further, the Hanovia xenon-arc lamp being an enclosed bulb-type source makes possible an optical system that is closely coupled, and therefore of small size and relatively inexpensive.

(2) Second, the transparency of the arc makes the use of a reflector highly effective. In the Navy AQ-2(1) Sound Motion-Picture Projector the reflector when used with a tungsten incandescent lamp increased projected screen illumination 16 to 18%, while with the xenon-arc lamp the same reflector in the same projector increased projected screen illumination 60 to 70%.

(3) Third, even though the overall light output of the Hanovia xenon-arc lamp has an average color temperature of approximately 5200 K, the center of the arc has a lower color temperature that is entirely compatible with color film processed for the tungsten incandescent lamp.

(4) The fourth characteristic of the Hanovia xenon-arc lamp, and the most novel one, is that the light output from the arc can be pulsed in such a manner that the lamp acts as both light source and shutter. This means that the Hanovia xenon-arc lamp consumes power only when usable light is being projected on the screen and all the xenon-lamp light output reaches the screen. There is no 33 to 50% light loss due to a mechanical shutter blocking the light output from the lamp as in a normal motion-picture projector.

The pulsing of the light in the Hanovia xenon-arc lamp has two other useful effects. First, for the same average electric power into the xenon-arc lamp the higher instantaneous current during each pulse causes the arc to have a higher intrinsic brightness which gives 10 to 15% greater screen brightness for the same power consumed by the xenon-arc lamp. Second, the electrode life is increased and electrode evaporation is reduced because of the "rest period" between pulses.

The xenon lamp shown in Fig. 3 has a center bulb diameter of $1\frac{1}{2}$ in. The total overall length between electrode extremes is $7\frac{3}{8}$ in. The enclosure is made of fused quartz which has the requisite strength at high temperatures.

The operating temperature raises the gas pressure to several times that existing at room temperature. However, the lamphouse affords complete protection from operational hazard. Additionally, the lamphouse door in the Navy AQ-2(1) xenon-lamp conversion is interlocked to prevent operation when

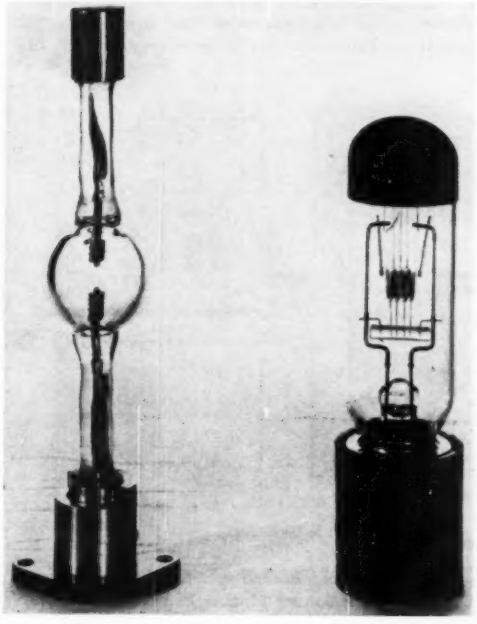


Fig. 3. (Left) The Hanovia xenon arc lamp as used in Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the xenon arc lamp conversion, compared to a standard 1,000-watt, 10-hour, tungsten incandescent projection lamp.

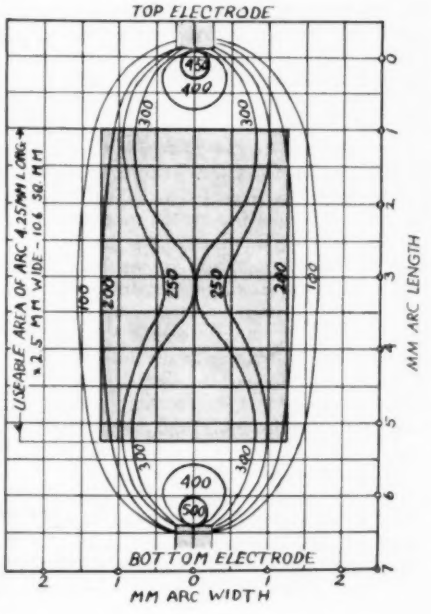


Fig. 4. Light distribution in the arc of the Hanovia xenon arc lamp with the arc image reinforced with an inverted reflected image.

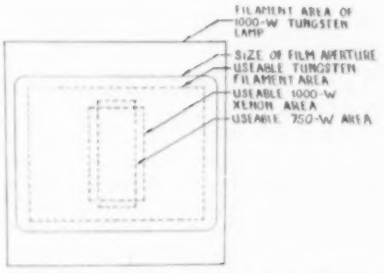

FILAMENT AREA OF 1000-W TUNGSTEN LAMP
SIZE OF FILM APERTURE
USEABLE TUNGSTEN FILAMENT AREA
USEABLE 1000-W XENON AREA
USEABLE 750-W AREA

Fig. 5. Relative sizes of the 1,000-watt, 10-hour, tungsten incandescent projection lamp filament and the Hanovia xenon lamp arc as compared to a 16mm film aperture.

open. During experimental development the xenon lamps have been shipped, mounted in the projector, by airplane, train, truck and auto without a single instance of breakage. We have not experienced any instance of lamp explosion with the lamps either hot or cold. The general opinion is that they are not quite as hazardous as television cathode-ray tubes.

The quartz-enclosed electrodes between which the arc occurs are made of exceptionally pure tungsten of adequate section to carry the requisite current.

Light Characteristics of the Xenon Lamp Arc

Figure 4 shows the light distribution in the arc of the Hanovia xenon-arc lamp with the arc image reinforced with a reflector, such as is used in the Navy AQ-2(1) projector optical system. Without the reflection the arc image would be wedge-shaped, with the narrow end of the wedge at the bottom electrode and the broad end of the wedge at the top electrode. The reflector used lays an inverted image of the arc upon itself and makes the arc symmetrical about its horizontal axis. As can be seen, the arc has "hot spots" at each end. The color temperature of these hot spots is upwards of 6000 K.

The shaded area shown on Fig. 4 is the center of the arc that is magnified and elongated horizontally and imaged upon the film aperture by a condenser system. Incidentally the rather peculiar "X"-shaped incidence of the light conduces to very uniform light distribution because it counteracts the normal corner "drop-off" in light on the screen due to lenses. This area of the arc projected upon the aperture and on the screen does not include the hot spots, since their high intrinsic brightness and high color temperature would cause bright bluish bands at the top and bottom of the screen. Further, the electrodes themselves are excluded from the area of the arc chosen for projection because they become incandescent and their light does not follow the pulsed light shape required for shutterless operation. Even though the light given off by the electrodes is minute as compared to the arc, a travel ghost would result. Under actual test, when electrode light was deliberately introduced, a travel ghost was readily seen on black-and-white test film because of its orange-red color rather than because of its intensity.

In the main, 16mm projection will always be predominantly with incandescent as a light source. This makes mandatory a close approximation to the light characteristics of the incandescent lamp in any high light output substitute for it. While the xenon-arc stream, as used in the Navy AQ-2(1) xenon-arc conversion, is higher in color temperature than the incandescent lamp, its light composition does present, because of its continuum with regard to color, an excellent actual compromise result. The Navy, through the facilities of the Brooklyn Motion Picture Exchange, has used it to screen the various color processes and has found a widespread audience reaction that the end result is most acceptable and pleasing. While the blues are somewhat accentuated, the balancing presence of red compensates for this.

Optical Considerations

Figure 5 shows the relative sizes of the tungsten incandescent light and the Hanovia xenon-arc light sources as compared to a 16mm film aperture as used in the Navy AQ-2(1) Sound Motion-Picture Projector.

As can be seen, the usable tungsten incandescent lamp area is of almost the same size as the 16mm film aperture; therefore the condenser system has only to take light from the tungsten incandescent lamp at the maximum useful lens aperture and redirect it on the 16mm film aperture in such a way that the projection lens operates at full aperture for maximum projected light on the screen.

However, the usable area of the xenon arc must be considerably magnified, horizontally more than vertically, in order to fill the film aperture. This was further complicated by the fact that for maximum usefulness the conversion of the Navy AQ-2(1) 16mm Sound Motion-Picture Projector required simplicity and a minimum of replacement parts. Therefore, the reflector for the xenon lamp was to mount in the same holes, the xenon lamp socket was to mount in the same holes in the same adjustable base as the tungsten lamp socket, and the xenon-arc condenser lenses were to be directly replaceable in the same lens holder. Also all existing projection lenses of different focal lengths for the Navy AQ-2(1) projector had to be accommodated at full efficiency.

Figure 6 is a graphical picture of the complete light and optical system for the Hanovia xenon-arc lamp in the Navy AQ-2(1) 16mm Sound Motion-Picture Projector, while Fig. 7 is a photograph of the same. In this photograph the lamp housing and the condenser housing are removed. Also the mechanical shutter is removed for shutterless operation. The lens spacings shown are obtained by replacing the standard Navy AQ-2(1) condenser lenses with the new xenon-lamp condenser lenses, while the Hanovia xenon-arc lamp spacing is obtained by replacing the tungsten incandescent lamp socket with the xenon-lamp socket.

The same reflector is used as in the standard AQ-2(1) projector.

Pulsed Light or Shutterless Operation

Figure 8 shows graphically the shape of the light pulses from the Hanovia xenon-arc lamp and how the film pull-downs are accomplished during the xenon-arc "dark-out" periods. A rate of 120 light pulses/sec was chosen because this can be most conveniently ob-

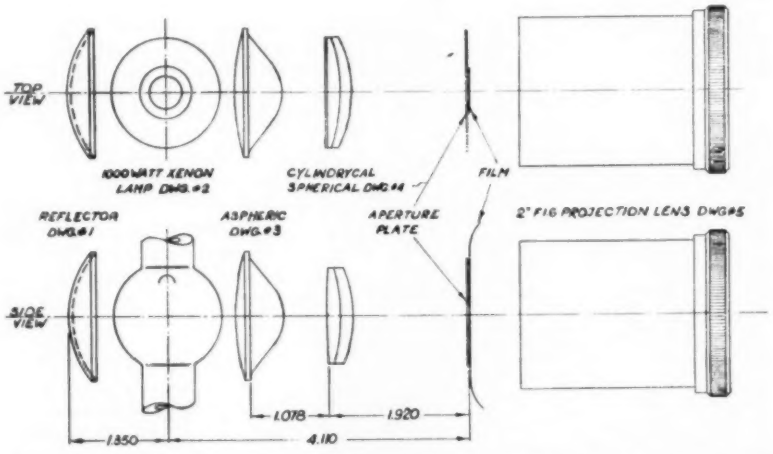


Fig. 6. A pictorial layout of the complete light and optical system of the xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

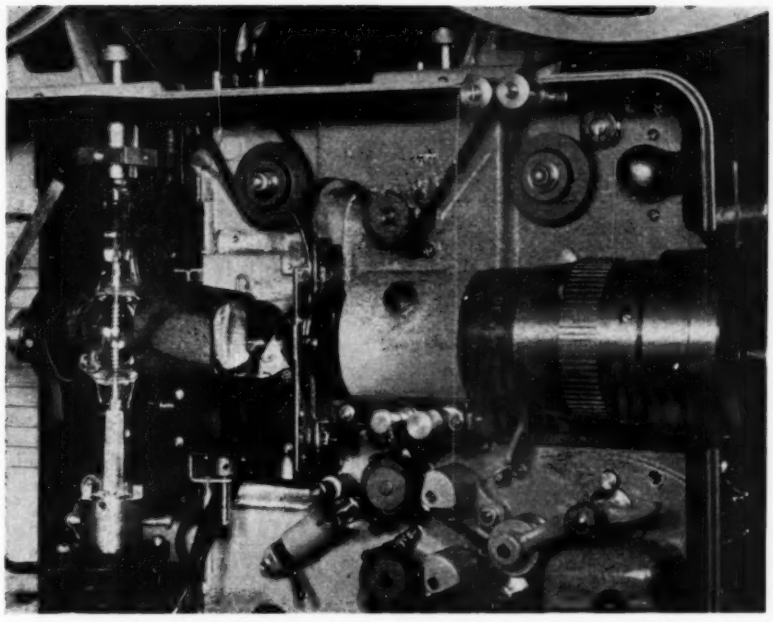


Fig. 7. The light and optical system of the xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

tained directly from a 60-cycle power line and because a synchronous motor driving the projector from the same 60-cycle power line will always synchronize the film pulldowns with the xenon light "dark-out" periods. As can be seen, this gives five light interruptions per frame of 16mm motion-picture film at the sound speed of 24 frames/sec, resulting in completely flicker-free projection.

Figure 9 shows the synchronous motor conversion kit necessary to convert the Navy AQ-2(1) Sound Motion-Picture Projector to Hanovia xenon-arc lamp shutterless operation, while Fig. 10 shows the synchronous motor mounted in the projector replacing the standard AQ-2(1) universal motor.

Ballast

The Hanovia xenon-arc lamp requires a ballast and a starter in order to strike the lamp automatically and to operate it in such a way that a pulsed light output is obtained. As a design objective, every effort was made to design a ballast using only static transformers and condensers. No components of limited life that required periodic replacement were to be used. Further, the use of complex electromechanical devices, for timing or sequencing, was avoided to eliminate adjustment and service requirements. These design objectives were in keeping with the requirements of the Navy for the usage of this equipment.

Naturally, the least possible weight and size of the ballast would be most desirable; however, it was felt that maximum portability and usefulness could be retained if the automatic ballast starter did not exceed the Navy AQ-2(1) 16mm Sound Motion-Picture Projector in size and weight. Due to basic design objectives for operation and safety, which could not be sacrificed, and worthwhile features that should be included for convenience and ease of operation, this was quite difficult to accomplish. However, by designing the transformers for class H insulation and using the best grades of transformer lamination, the weight was brought down to 55 lb, cables included.

Figure 11 shows the circuit of the automatic ballast, starter and xenon lamp. At the left are the components that go in the separate ballast package; in the center is the interconnecting cable; on the right are the starter components that are fastened on the lamphouse door. Mounting the starter components on the lamphouse door places the rf(radio-frequency) striking voltage directly on the lamp and simplifies shielding for safety from high voltages. The interlock on the lamphouse door will shut off the lamp and kill all high voltages by opening the line contactor in the ballast. The line contactor will also open if the interconnecting cable is disconnected so

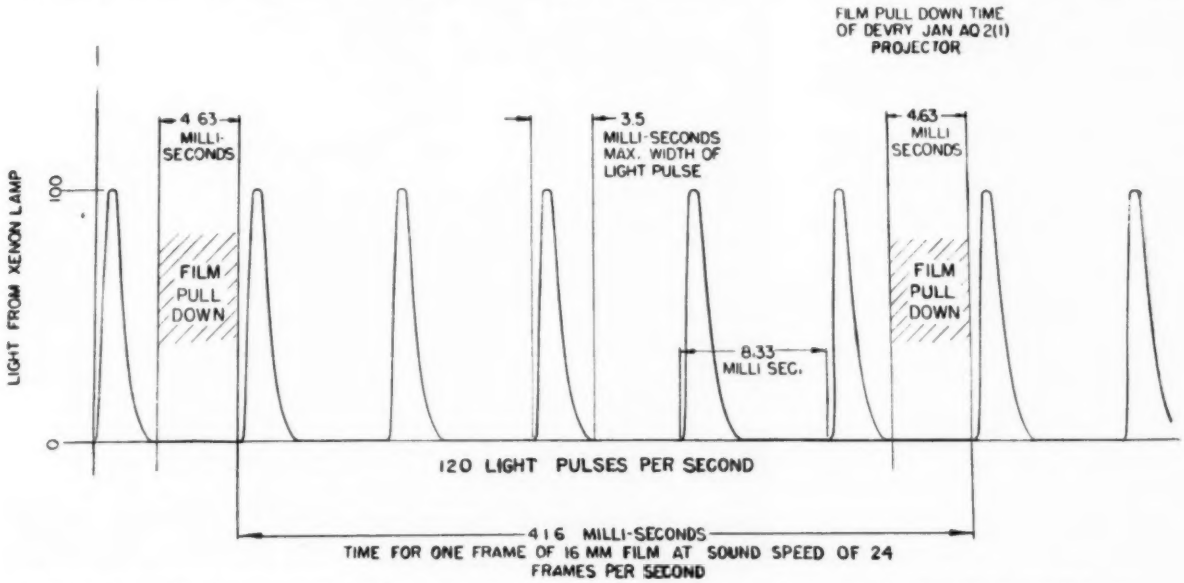

FILM PULL DOWN TIME OF DEVRY JAN AQ 2(1) PROJECTOR
4.63 MILLI-SECONDS
3.5 MILLI-SECONDS MAX. WIDTH OF LIGHT PULSE
4.63 MILLI SECONDS
LIGHT FROM XENON LAMP
100
0
FILM PULL DOWN
FILM PULL DOWN
8.33 MILLI SEC.
120 LIGHT PULSES PER SECOND
41.6 MILLI-SECONDS
TIME FOR ONE FRAME OF 16 MM FILM AT SOUND SPEED OF 24 FRAMES PER SECOND

Fig. 8. A graphical representation of the light pulses from the Hanovia xenon arc lamp showing how the film pull-downs are accomplished.

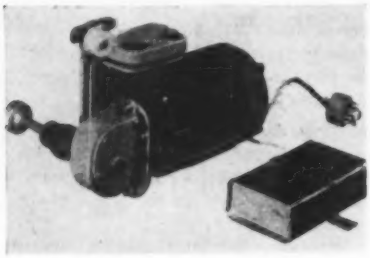


Fig. 9. The synchronous motor conversion kit for the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

that no line plugs or line cable ends can be encountered.

Operation of Ballast

Figure 12 shows the approximate voltages and currents in the ballast starter circuit while the lamp is striking, but before it has struck. Figure 13 shows the approximate operating currents and voltages after the lamp has struck and is operating and giving a pulsed light output.

The "peaking transformer" is a saturated iron-core reactor that distorts the current waveshape such that the Hanovia xenon-arc lamp gives a pulsed light output.

The "ballast and starter transformer" in conjunction with the "striking condenser" supplies the starting currents and voltages and operating currents and voltages at terminals (2) and (3) to complement the electrical characteristics of the Hanovia xenon-arc lamp. Also the "ballast starter transformer," by acting as an autotransformer, reduces the line demand of the ballast. Further, the circuit of "peaking transformer," "ballast and starter transformer," and "striking condenser" tends to regulate the Hanovia xenon-arc lamp current, and consequently light output, for varying line input voltage.

Now before a simplified explanation of the operation of the ballast is made, the striking, starting and operating characteristics and requirements of the Hanovia xenon-arc lamp will be mentioned. The rf striking circuit consisting of "high-voltage transformer," "spark gap," "condenser" and "pulse transformer" will be considered as part of the xenon-arc lamp circuit that the ballast must supply and complement.

Figure 14 shows the starter on the lamphouse door with its cover removed. On top is a small blower that supplies additional cooling to the top of the Hanovia xenon lamp in the lamphouse. In the center is the "pulse transformer," on the bottom is the "spark gap" covered with an insulating housing, and behind the spark gap is the "condenser."

To start the Hanovia xenon lamp requires 150 v of line frequency. With the 150 v available the rf striking circuit is energized and the lamp is struck. However, the lamp when struck will not start unless approximately 900 va(volt-amperes) is available from the 150-v initial voltage to 30-v operating voltage. The higher the volt-amperage available, initially at strike, the quicker the xenon lamp will start. However, to exceed 900 va, which is the operating volt-amperage, at strike may reduce useful lamp life due to electrode evaporation and bulb blackening in the lamp. Therefore, the xenon lamp and rf striking circuit require 150 v at strike, with 900 va available from 150 v strike and start to 30 v operating. At 30 v and 30 amp operating, the rf striking circuit is inoperative because not enough voltage is available from the "high-voltage transformer" to discharge across the "spark gap."

If only the "peaking transformer" and winding No. 1 and winding No. 2 of the "ballast and starter transformer" are connected to the line (see Fig. 12), but the "striking condenser" is not in the circuit, the "peaking transformer" and winding No. 1 and No. 2 of the ballast starter transformer will divide the 115-v line voltage and only a small exciting current will flow. The voltage available at (2) and (3) would be approximately 40 v at no load. With a load across (2) and (3) not more than 350 va could be drawn.

If only the "striking condenser" and winding No. 3 of the "ballast starter transformer" are connected across the line, but the "peaking transformer" is not in the circuit, a heavy current, 7.5 amp, will flow in this series circuit. The impedance of this series circuit consists of only a small inductive reactance, since the capacitive reactance of the "striking condenser" partially cancels the inductive reactance of winding No. 3. However, individually the impedances of the inductive and capacitive reactances are high and the 7.5-amp current causes a voltage drop of approximately 540 v across the condenser and approximately 430 v across the winding No. 3. Now, since winding No. 3 is on the same core as winding No. 2, a voltage of approximately 150 v is induced across winding No. 2 across points (2) and (3).

If the peaking transformer is now put into the circuit, it acts as a high impedance partially isolating point (1) from the line such that the voltage at winding No. 2, points (2) and (3), is determined by the voltage across winding No. 3 rather than by the line. With the higher voltages across windings No. 2, No. 1 and the peaking transformer, a somewhat higher exciting current is drawn through these windings.

Now, with 150 v across points (2) and (3), the rf starter strikes the xenon lamp and the lamp starts to draw 900 va. This volt-amperage, while the lamp current is low and the lamp voltage high, is mostly supplied by the series circuit of "striking condenser" and winding No. 3, and partially by increased exciting current through the peaking transformer as the lamp load across winding No. 2, points (2) and (3), lowers the impedance of winding No. 2. As the lamp heats up, its impedance drops and an increased current flows through it, caus-

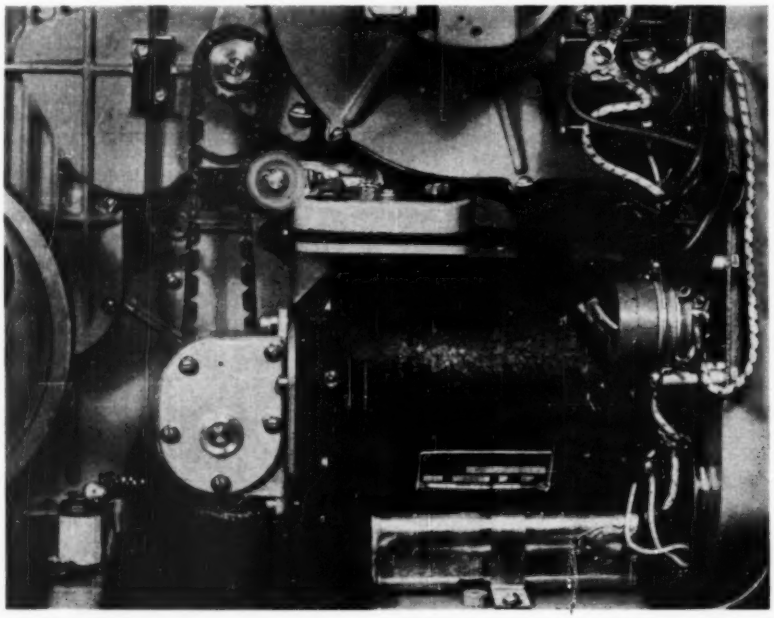


Fig. 10. The synchronous motor mounted in the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

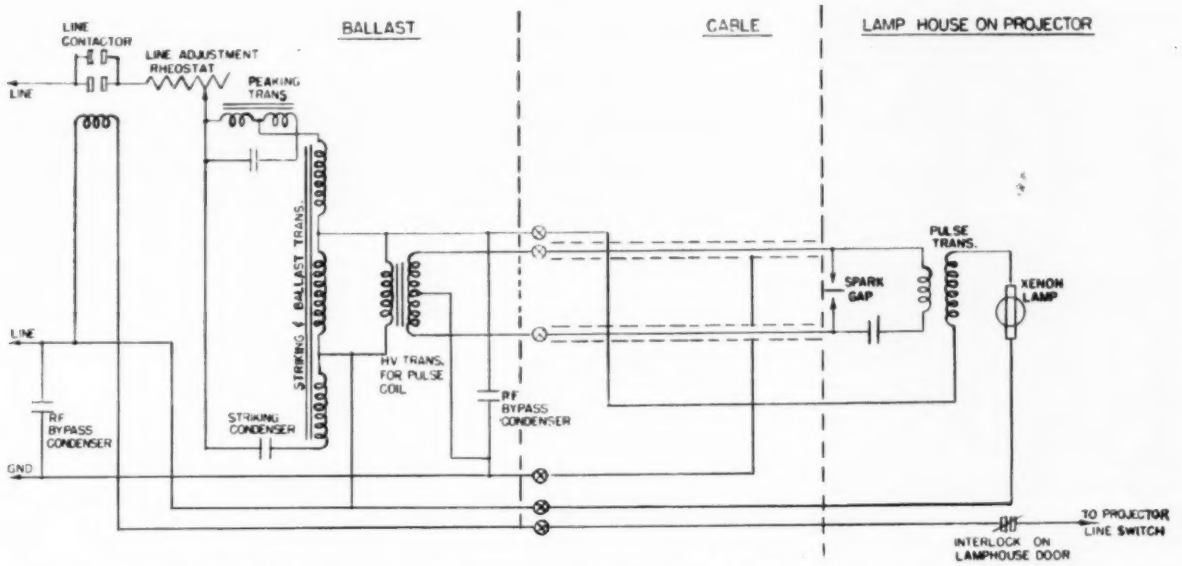


Fig. 11. Wiring diagram of the automatic ballast, the starter and the Hanovia xenon arc lamp.

ing the voltage across winding No. 2 to drop. At this point both the line through the "peaking transformer" and the series circuit of "striking condenser" and winding No. 3 are supplying power to the xenon lamp. With increased current through the lamp, the current through the "peaking transformer" causes a higher voltage drop across it, which reduces the voltage of winding No. 2. The higher current through winding No. 1 and No. 2 causes a bucking current in winding No. 3 that reduces the current through the series circuit of "striking condenser" and winding No. 3, that reduces the voltage across winding No. 3, that reduces the voltage induced into winding No. 2. This bucking current through winding No. 3 finally increases to a point where it is greater and there is a reversal of current through the series "striking condenser," winding No. 3 circuit. Due to the parameters of the circuit, this action continues until a stable point is reached where the lamp operates at 30 v and 30 amp.

The bucking current through winding No. 3 circulates through the peaking transformers, windings No. 1, No. 2, No. 3 and the striking condenser (see Fig. 13). This bucking current increases the saturation of the peaking transformer and raises the voltage across the peaking transformer. With the peaking transformer at a higher voltage, separated by the turns ratio of winding No. 1 and No. 2, the effect of line variation on lamp voltage and current is minimized. Further, the circulating bucking current opposes current change in the circuit. Thus, fairly good lamp-current regulation is achieved.

This explanation of the automatic starter ballast is only approximate due to its high harmonic content. The

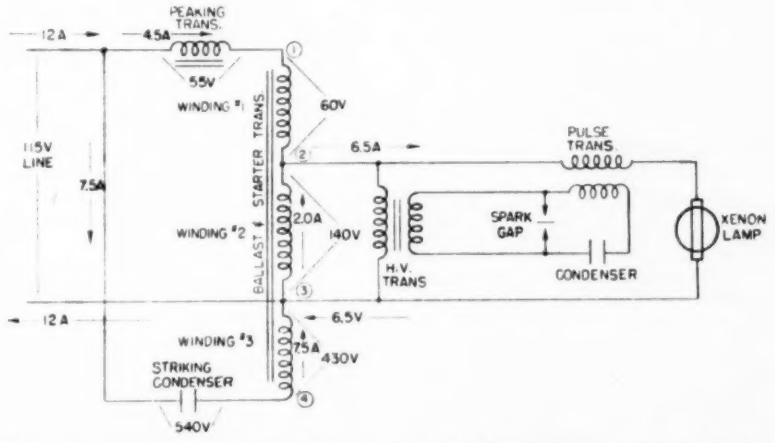


Fig. 12. Approximate voltages and currents in the ballast-starter circuit while the Hanovia xenon arc is striking, but before it has struck.

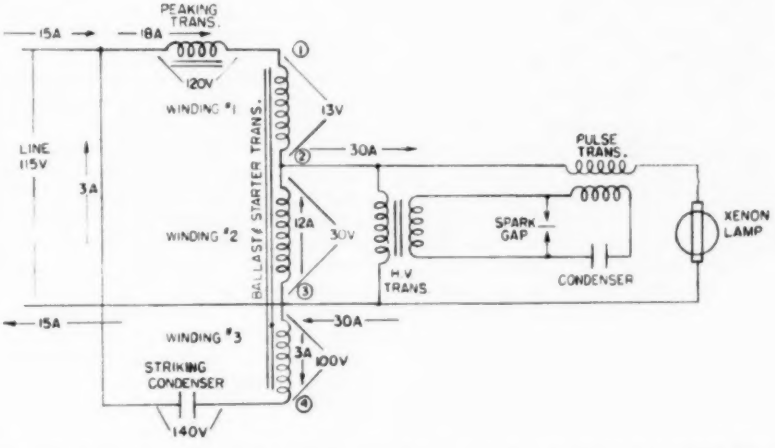


Fig. 13. Approximate operating currents and voltages after the lamp has struck and is operating with pulsed light output.

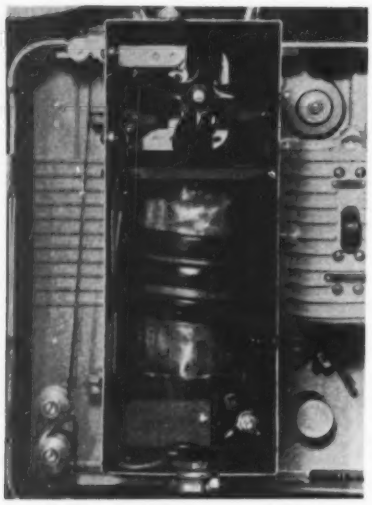


Fig. 14. The starter, with cover removed, mounted on the lamp house door of the Hanovia xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

values of current and voltage shown on Fig. 12 and particularly on Fig. 13 are approximations for this reason.

Other Applications of the Xenon-Arc Projector

The pulsed light output from the xenon-arc lamp conversion of the Navy AQ-2(1) projector having a frequency of 120 light pulses, or fields, per second immediately suggested itself for television use, where 60 light fields, lace and interlace, per second give 30 pictures per second. As it happened, a vidicon television camera was in use for 16mm motion-picture pickup in the same projection room where the xenon-arc lamp projector was being tested; therefore, the xenon-arc lamp projector was simply substituted for the special 16mm, mechanically shuttered, 60 light fields/sec, television film projector. At the time it was a surprise that the xenon-arc lamp projector, with its 120 light pulses/sec, or two light pulses per television field, produced a television picture having uniform light distribution. Further, all the difficulties of poor television picture light distribution and application bar that had been encountered with the mechanically shuttered television projector were eliminated, since the poor television picture light distribution was due to the transit time of the mechanical shutter and due to imaging behind the motion-picture film upon the shutter blades, because of increased depth of focus of the projector and television camera optical systems, and the application bar was due to minute imperfections in shutter blade width and spacing.

These results led to further tests on television pickup of 16mm motion-picture projection with both image-orthicon and vidicon television cameras. It was found that the image persistence of both cameras was great enough so that having two separate light pulses per television field was not detrimental to picture light uniformity.

One interesting feature was brought out when the xenon-arc lamp projector was used with a rear-projection screen for television stage backgrounds. The general foreground stage lighting could be increased and even directed upon the rear-projection screen until the image of the xenon-arc lamp projector picture was washed out. However, the image persistence of the television camera retained the peak intensity of the xenon-arc lamp pulses. Therefore, the television picture showed the background rear-projection image at full contrast, while the eye seeing the average light from xenon-arc lamp pulses saw the rear-projection image on the stage washed out by the foreground lighting.

The xenon-arc projector was also excellent for television color film pickup, because of the abundance of light, the television color-separation process being exceedingly wasteful of light. Further, the continuous color spectrum of the xenon-arc lamp made color balancing of the three color images easy to accomplish.

At this time we want to thank Philip M. Cowett of the Navy Bureau of Ship, who first recognized the possibilities of the xenon-arc lamp for 16mm motion-picture projection and for all the help and suggestions he gave us on this Navy project; Dr. W. T. Anderson, Jr., Director of Research, and J. F. Postell, of the Hanovia Chemical and Mfg. Co., for their cooperation in the development of the lamp that made the success of this Navy project possible; and Walter A. Lotz for the optimistic assistance he gave the authors in the field of optics and the many others who contributed their efforts and encouragement in this project.

It is our feeling that the xenon-arc lamp as a new light source with its many novel and unique characteristics has possibilities not only in the motion-picture field but in all fields where a color-balanced light is required. The high-pressure xenon-gas quartz lamp may usher in a new era of high-efficiency light output devices. It has been a privilege to the authors to contribute in some small degree to this basically new art.

Discussion

L. L. Behrmann (Army Medical Service): What is the possibility of using this lamp in a television system?

Mr. D'Arcy: We've had very good success with this light source in television. We've had no shutter-bar. It surprised me how effectively the lamp functioned. In the case of television, of course, everything is limited by the 60-cycle light source, giving two pulses per field. You might expect that one would get a little frame dark spot at the top and bottom of each field and a bright spot in the center. However, we have not encountered these. Apparently there is sufficient storage capacity in the present camera tubes, both the image orthicon and the vidicon, to make this a very practical way of doing the job.

Mr. Behrmann: Is it possible to obtain this lamp in a smaller wattage?

Mr. D'Arcy: Definitely.

Walter I. Kisner (Eastman Kodak Co.): Have you made any measurements with respect to the heat at the aperture when this lamp is used, relative to that when a tungsten lamp of equivalent wattage is used?

Dr. Anderson: Not as yet. The xenon lamp does not produce as much heat as the Mazda Lamp operating at the same power. It is cooler. I think it produces about 80% of the temperature.

Anon: On smaller screens is there an adjustment for operating at less than 2000 lumens?

Dr. Anderson: Yes, you can reduce the power input to the lamp. I understand that the color temperature decreases somewhat, which is rather favorable if you are going to consider the fact that prints may have been matched to the color of Mazda and not that for the xenon source.

Mr. D'Arcy: The color temperature doesn't change radically. In other words, when Dr. Anderson spoke of color temperature dropping with lower current, I don't think it is a very drastic change — a few hundred degrees at the most.

R. T. Van Niman (Radio Corp. of America): What is the weight of the power supply? I can see that it is rather small but is it very heavy?

Mr. D'Arcy: The power supply weighs 55 lb. The weight of the projector itself is increased an additional four pounds by the weight of the lamp and the coil and spark starting mechanism.

R. A. White (General Precision Laboratory): I notice in Mr. D'Arcy's lantern slide illustrating the timing cycle that the film pulldown takes place between the light pulses. I presume that the projector used in the demonstration was performing in this manner. Did you have to increase the speed of pulldown on the standard projector to accomplish this?

Mr. D'Arcy: Our projector has a 40° pulldown.

Mr. White: 40°?

Mr. D'Arcy: That's correct. And that's adequate to do the job. Mr. Seda had quite a bit of romance in shaping the pulse. That's a different story. It's not only the pulldown, but it's also the electrical shaping of the pulse which makes this job possible.

Mr. White: I was thinking in terms of television projection which you mentioned.

George Lewin (Signal Corps Pictorial Center): I noticed that it seemed to take a little time to start the arc. Is that typical or can this be resolved?

Mr. D'Arcy: I think we can make improvements in the starter. This is not the ultimate in starters as yet and for some reason, this being a time when it would act up a little bit, it isn't doing the job the way it normally does. Normally the arc should start immediately after the first starting pulse. You can understand my unwillingness to delve into the equipment at this time to improve the performance.

Electronic Flashlamps

By HARRY L. PARKER

The increased use of xenon-filled flashtubes for commercial, illustrative, scientific and industrial fields is reported along with an analysis of the advantages obtained. Factors that should be considered in applying electronic flash are defined along with a report on efforts to obtain uniformity in the definition of terms. New applications of standard single-flash and repetitive-flash equipment in photoinstrumentation, photocopy and industrial research work are described.

THE HISTORY of electronic flash is, of course, part of the history of high-speed photography itself. As early as 1852, H. Fox Talbot suggested that "it is in our power to obtain pictures of all moving objects, no matter in how rapid motion they may be, provided we have the means of sufficiently illuminating them with a sudden electric flash . . . . "

In 1878 Dornesthorpe published an account of a method of projecting transparencies by means of a series of flashes from a vacuum tube. Ottaman Anschütz carried this technique farther and by 1884 had produced creditable pictures of birds in flight. From 1885, he carried out work very similar to that being done by Muybridge. Starting in 1881, Ernest Mach, assisted later by his son Ludwig Mach, used electric sparks for photography in ballistic studies.

Around 1890, Sir Charles Boys took shadow photographs of projectiles, similar to those taken earlier by Mach. However, Boys succeeded in obtaining greater information by measuring the duration of the spark. He recorded a reflection of it from a rapidly revolving mirror on a photographic plate and measured the length of the trace — a method which we still use today.

The light flash produced by the spark discharge was limited and the use of this technique for illuminating a subject was confined to small areas.

High-speed photography continued its advance with the introduction and improvement of components, systems and techniques. One of the main obstacles was the difficulty in obtaining adequate lighting for nonluminous subjects. In 1931, Harold E. Edgerton pointed out that a mercury arc could be made to give short flashes of highly actinic light. This provided higher efficiency of utilization as compared with a continuous source of high intensity. It also made possible the omission of both the shutter and optical compensator. Edgerton demonstrated a film made in this way, with individual exposures of less than 10 μsec, of a synchronous motor pulling into step.

Presented on May 6, 1954, at the Society's Convention at Washington, D.C., by Harry L. Parker, American Speedlight Corp., 480 Lexington Ave., New York 17.
(This paper was received on May 26, 1954.)

This development by Edgerton is considered the start of electronic flash as we know it today. Edgerton continued his work in this field, developing improved control circuits and discharge tubes. By 1938, basic circuits and tubes of the type used today were developed, though it is now less used for cinematographic work than for single flashes.

The light output and operating characteristics of the xenon-filled flashtube made it a very important light source for photography, including the fast developing field of color photography. The characteristics are: (1) spectral distribution similar to daylight; (2) cool, because of high efficiency of utilization; (3) flashes are uniform and reproducible; (4) clean; (5) economical; (6) high-peak illumination; and (7) high speed.

The recognition of these factors is the reason why today electronic flash (also called speedlight or strobe) is a major light source in photography, particularly professional and commercial still photography.

With the tremendous growth of photography in industry, electronic flash is being used in an ever-increasing number of applications. In fact, it is well to consider the use of electronic flash where the above factors are important enough to become the deciding factors.

With the increase in application, however, there comes a need for a more definite understanding of all operating characteristics. Many people now using, or who want to use, electronic flash are primarily photographers and not research scientists. Many have considered electronic flash as some mysterious black magic; therefore, definition and standardization of the terms used in this work are important. It is felt that such definitions and standardization of terms will help photographers in industry and research to use this important light source effectively.

From the standpoint of practical application, the factors that should be known about any light source are: (1) spectral distribution (most speedlight units can be considered approximately the same); (2) strength of light (measured in beam candlepower seconds); (3) the angle of coverage of the reflector; and (4) the duration of the flash.

1. The wedge spectrograms, as shown in *High Speed Photography* by George A. Jones, show the similarity of the output of the flashtube to that of daylight.

2. Unfortunately, most photographers rate electronic flash in terms of watt-seconds. This is a measure of energy storage, not light output. Therefore, it is felt that the sooner we start rating electronic flash in terms of light output, the better it will be. The candlepower-seconds as measured on the beam of the reflector (bcps) is one convenient method.

3. The angle of coverage of the reflector is a factor which requires defining the method of measuring and the limits involved. In the survey that has been made concerning these factors, the consensus of opinion indicates that the reflectors should be rotated on a pivot which is marked with a compass, and the meter or receiver should be in a fixed position. It is further felt that the limits in defining angle of coverage of the reflector should be at the angle at which the light output falls to one-third the value, obtained on the axis. This angle off axis would represent the one-half angle of the reflector. In other words, a reflector whose output at 30° off axis dropped to one-third of that measured on the axis, would be defined as a 60° reflector.

4. Duration of flash is important because of many considerations: image motion, reciprocity failure, etc. This also needs defining. Figure 1 shows a typical discharge curve of a flash discharge. Various points of definition have been used by different workers. However, from the consensus of opinions expressed in the survey, it seems that the time between the third-power points should be the point of measurement used for defining the discharge time of electronic-flash equipment.

(5) Of importance in the application of electronic flash is the recharge time. In normal condenser charging, the voltage on the condenser rises exponentially. Since light output varies as the square of the voltage, it is necessary to have the voltage as near the 100% value as possible when flashing. As a practical matter, the 90% voltage point is defined as the point for defining recharge time of electronic-flash equipment. The recharge time is also one of the limiting factors in cinematographic applications (Fig. 2).

In the application of electronic flash for repetitive flashing, the limiting factors are: (1) average power-handling capabilities of the tube which are affected by (a) repetition rate; (b) energy per flash; and (c) cooling or heat dissipa-

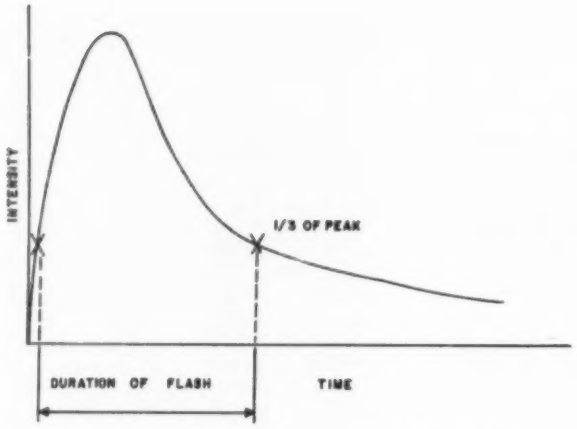


Fig. 1. A typical discharge curve of a flash discharge.

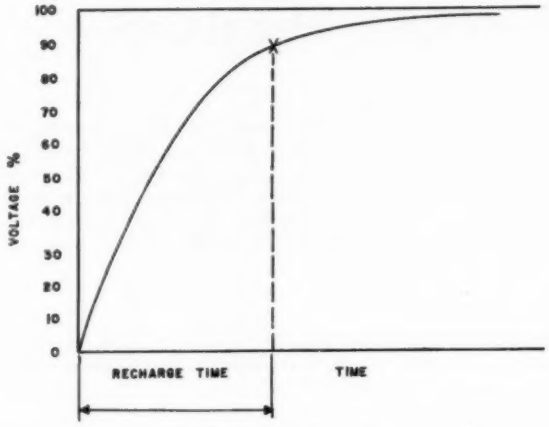


Fig. 2. Recharge of condenser.

tion; (2) recharge time; (3) deionizing of tube (holdover); and (4) duty cycle.

At the present time there are several standard repetitive flashing units on the market. Custom-built equipment is also available to meet specific requirements of an application. The requirements of repetitive flashing equipment vary considerably in regard to both maximum repetitive flashing rate and amount of power per flash. In estimating the power requirements of a repetitive flashing unit, the power per flash times the maximum flashing rate per second indicates the average wattage consumption of the flashtube. The limiting component is the flashtube and the maximum average power that it can handle. When a flashtube is used for single flash work, the tube can handle considerably more power per flash than it can in average power for repetitive flashing.

In designing equipment for repetitive flashing, it is necessary to know the type of work, the number of flashes per second that are required, and the amount of light per flash that is required; or else the photographic exposure, the type of materials and the light-to-subject distance. It is also necessary to know the maximum duty cycle operation that will be required of the equipment.

There is an ever increasing use of electronic flash in industry for various applications such as: (1) illuminating panels and dials for data recording; (2) illuminating counters for time base; (3) study of simultaneous events; (4) copying, particularly of color artwork; (5) large-area illumination where motion is involved; (6) sequential pictures for individual frame analysis; (7) multiple images on a single picture; and (8) time-lapse work.

Discussion

Henry Roger (Rolab Studios): In taking photomicrographs with a photoflash, it would be necessary, of course, to have a pilot light with which to focus. This is especially true at high magnification. Now, the spectral characteristics of the pilot light should approximate those of the photoflash. What has been done in this respect?

Mr. Parker: Several things have been done to help solve the problem of focusing. In focusing for the photomicrographs that I showed, Julius Weber, who did these particular shots, simply put a photoflood bulb in front of the speedlight unit and focused on the subject. Another way has been to use a flashtube with a modeling light, which is in the center of the helix. A third way of doing it on instruments such as the Leitz Panphot, where there are two optical paths, is to use a Mazda bulb with appropriate filters for focusing and then by "flipping" the mirror, the speedlight light source is substituted for the actual photomicrograph.

Mr. Roger: There is, of course, a difference of color temperature between the electronic and the Mazda light source. What is it approximately?

Mr. Parker: As I pointed out, electronic flash is similar to that of daylight and you would use daylight color materials unless you were using selective filtering. Now, we have done work with all types of color materials, including Ektacolor Print film, etc., and we find that by using selective filters, you can do quite a few tricks with electronic flash. Now, as you know, in photomicrography you often have to use selective filtering to bring out the type of subject. You might be interested to know that in the October 1953 issue of the AMA Journal, the phase micrograph that was on the cover was made with electronic flash 1000 X magnification.

Another technique that is used, particularly on high magnifications of still subjects with small equipment, is a matter of repetitive flashing (flashing the light a number of times). Of course, where there's movement of live subjects, you have to have a single flash. For higher magnifications, it means more power per flash to do the job.

Mr. Roger: With regard to single-flash equipment, I believe it should not be called "strobe flash" or "strobe light" as so many call it.

Mr. Parker: I agree. Strobe, in my mind, implies repetitive flash. In fact, the term "Strob" is a copyrighted term of one of the manufacturers in this field. We, too, often say strobe for this type of lighting, even though we know it isn't exactly what we mean.

The matter of the term watt-seconds is also a point that authorities in the field should understand. We should stop talking about watt-seconds as a rating of electronic flash, but talk about the light output. It will help propagate the proper use of the terms and ratings.

Kenneth Morgan (Interchemical Corp., New York): Was the curve showing duration versus intensity produced by an oscillograph?

Mr. Parker: That particular curve was just an approximate curve made on a piece of graph paper. We do make our curves with an oscilloscope, a single-trace oscilloscope, such as the Du Mont 294A, with a phototube pickup.

Mr. Morgan: Have you arrived at any conclusions as to how you relate a curve of that type to the film in use?

Mr. Parker: The matter of defining the duration of the flash is one of agreeing on a point on the curve as a means of definition. This is one of the terms that has been discussed in surveys. For practical purposes, the time between the three power points has met with widespread agreement as the points of definition. Below the one-third point the light is not too effective for practical purposes. However, in the case of a high light, such as photographing a swinging golf club that is highly reflective, the "tail" of the curve is still effective. Therefore, when you get into exacting scientific work, it is necessary to have more precise definitions as to the duration of the flash, than we normally give for the average type of commercial and illustrative photography.

Engineering Activities

New Index

A new index to American Standards on Cinematography, dated September 1954, has just come off the press and will be distributed to all members of the engineering committees. Other interested parties may receive a free copy of this index upon written request to the Society headquarters.

The previous index was issued February 1953. Since that time the process of revising outmoded standards, reaffirming standards still valid and adding new standards has continued apace and introduced sufficient changes to warrant the issue of this new index. Those who maintain a close watch on the status of existing standards would do well to have a copy of this latest issue.

American Standards on Cinematography may be purchased directly on order from the American Standards Association, 70 East 45 Street, New York 17, N.Y.—*Henry Kogel,* Staff Engineer.

Proposed Revision of Three American Standards PH22.15, –.16, –.28

Proposed revisions of three American Standards are published on the following pages for a three-month period of trial and criticism. All comments should be sent to Henry Kogel, SMPTE Staff Engineer, prior to December 15, 1954. If no adverse comments are received the three standards will then be submitted to ASA Sectional Committee PH22 for further processing as American Standards.

PH22.28, Projector Lenses for Motion Picture Theaters, revises the existing standard by eliminating references to (1) projection angle, (2) observation port and (3) projection lens mounting and also by several editorial modifications including change in title.

PH22.15, 16mm Film Perforated One Edge — Usage in Camera and PH22.16, 16mm Film Perforated One Edge — Usage in Projector, have modified the previous standards by (1) elimination of the guided edge specification, (2) addition of a $\pm\frac{1}{2}$ frame tolerance on the 26 frame sound to picture spacing and (3) several editorial modifications including change of title. The 16mm & 8mm Committee intends to resolve the guided edge question through the issuance of Society Recommendations providing the history and background of the question and recommendations as to preferred trends.

The 16mm standards were approved by the 16mm & 8mm Committee; the projection lens standard was approved by the Film Projection Practice Committee and all three were approved for this trial publication by the Standards Committee.—*H.K.*

Proposed American Standard

Projection Lenses for Motion-Picture Theaters

PH22.28

(Revision of Z22.28-1946)

1. Projection Lens Height

1.1 The height from the floor to the center of the projection lens of a motion-picture projector shall be 48 in., when measured with the projector at zero degree tilt.

2. Projection Lens Focal Length

2.1 The focal length of motion-picture projection lenses shall increase in ¼-in. steps up to 8 in., and in ½-in. steps from 8 to 9 in.

3. Projection Objectives, Focal Markings

3.1 Projection objectives shall have the equivalent focal length marked thereon in inches, quarters, and halves of an inch, or in decimals.

3.2 The tolerance of the designated focal length shall not exceed ± 1%.

NOT APPROVED

American Standards PH22.58, –.59, –.95, –.96-1954 and Withdrawal of Z22.54-1946

Published on the following pages are two new standards, PH22.95,–.96 and revision of American Standards PH22.58 and –.59.

The two new television standards, PH22.95 and –.96 were published for trial and comment in July 1953 along with an explanatory paragraph giving the basis for arriving at the specified dimensions.

Revision of PH22.58 and –.59 involved substantial modifications. The reasons for these modifications and the proposals themselves were published in October 1953.

On August 26, 1954, American Standard Method of Determining Freedom From Travel Ghost in 16mm Sound Motion Picture Projectors, Z22.54-1946, was withdrawn. The action was taken because the diamond target specified in that standard was considered unsatisfactory and the test film containing the target had not been generally supplied to the trade for many years. To fill this void, the 16mm & 8mm Committee is in the process of developing a replacement standard. In the meantime the Society is supplying a travel ghost test film with a more satisfactory rectangular target.—*H.K.*

A Graphic Language for those concerned with electrical diagrams has emerged from a complete revision and coordination of five American Standards for graphical symbols and is available from the American Standards Association, 70 E. 45 St., New York 17, under the designation American Standard Y32.2-1954. The 58-page Standard costs $1.25. The project was led jointly by the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. The Standard, containing single-line diagrams and simplified symbols, is of use in all electrical fields including radio and electronics, telephone, telegraph and power. Symbols already in use are included wherever possible, and the points of view of many groups are coordinated.

MEMBERSHIP CERTIFICATES

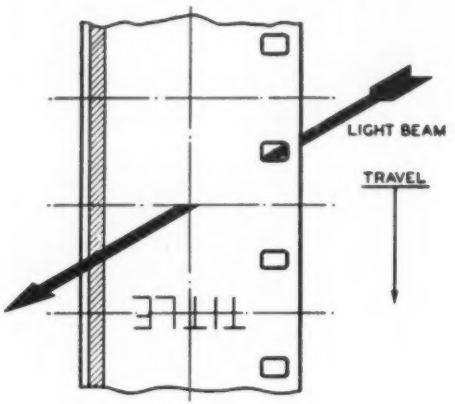
Society members have for many years purchased attractive hand-engrossed membership certificates for display in their offices or homes. These certificates were always priced, at least as far back as the records go, at $1.50. This is now less than their cost and so it has been necessary to increase the price of certificates effective October 1, 1954, to $2.50.

Proposed American Standard

16mm Film Perforated One Edge, Usage in Camera

PH22.15

(Revision of Z22.15-1946)



Drawing shows film as seen from inside the camera looking toward the camera lens.

1. Position of the Emulsion

Except for special processes, the emulsion shall be toward the camera lens.

2. Rate of Exposure

The rate of exposure shall be 24 frames/sec.

3. Relationship Between Sound and Picture

The apparatus and film shall be so arranged that the sound is placed on the film 26 frames, ± ½ frame, ahead of the horizontal centerline through the corresponding picture. Thus, a given point on the film shall pass the soundhead after it has passed the picture aperture.

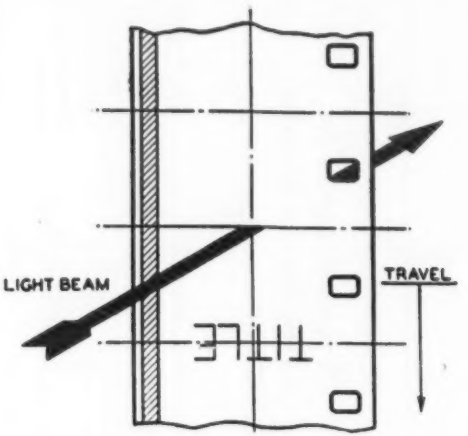
NOT APPROVED

Proposed American Standard

16mm Film Perforated One Edge, Usage in Projector

PH22.16

(Revision of Z22.16-1947)



Drawing shows film as seen from the light source in the projector.

1. Position of the Emulsion

Except for special processes, the emulsion shall be toward the projection lens.

2. Rate of Projection

The rate of projection shall be 24 frames/sec.

3. Relationship Between Sound and Picture

The apparatus and the film shall be so arranged that when the film is threaded normally, the soundtrack is scanned for reproduction at a point 26 frames, ± ½ frame, ahead of the centerline through the picture being projected. Thus a given point on the film shall pass the soundhead after it has passed the picture aperture.

NOT APPROVED

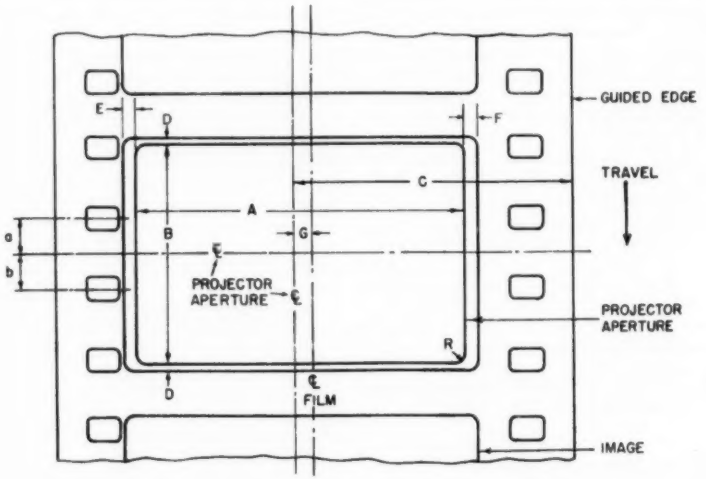
American Standard

Aperture for 35mm Sound Motion-Picture Projectors

ASA
Reg. U.S. Pat. Office

PH22.58-1954
Revision of Z22.58-1947

*UDC 778.554.4



Dimension	Inches	Millimeters
A	0.825 ± 0.002	20.95 ± 0.05
B	0.600 ± 0.002	15.25 ± 0.05
C	0.738 ± 0.002	18.74 ± 0.05
D	0.0155	0.394
E	0.022	0.56
F	0.021	0.53
G	0.049	1.24
R	Not > 0.005	Not > 0.13

a = b = ½ longitudinal perforation pitch.

These dimensions and locations are shown relative to unshrunk raw stock.

Note: The aperture dimensions given result in a screen picture having a height-to-width ratio of 3 to 4 when the projection angle is 14 degrees.

Approved August 13, 1954, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

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ASA½M954

Price, 25 Cents

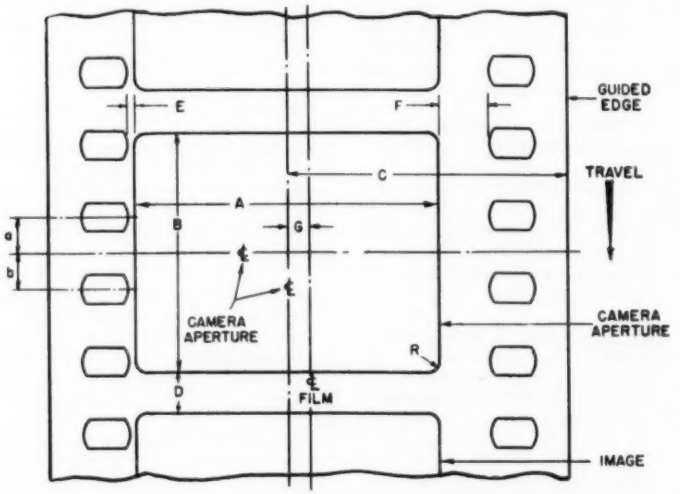
American Standard

Aperture for 35mm Sound Motion-Picture Cameras

ASA
Reg. U.S. Pat. Office

PH22.59-1954
Revision of Z22.59-1947

*UDC 778.53



Dimension	Inches	Millimeters
A	0.868 ± 0.002	22.05 ± 0.05
B	0.631 ± 0.002	16.03 ± 0.05
C	0.738 ± 0.002	18.75 ± 0.05
D	0.117	2.97
E	0.016	0.38
F	0.115	2.92
G	0.049	1.24
R	0.03 Approx	0.76 Approx

a = b = ½ longitudinal perforation pitch.

These dimensions and locations are shown relative to unshrunk raw stock.

Note: The aperture dimensions given in combination with an 0.600 × 0.825 in. (15.25 × 20.95 mm) projector aperture result in a screen picture having a height-to-width ratio of 3 to 4 when the projection angle is 14 degrees.

Approved August 13, 1954, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

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70 East Forty-fifth Street, New York 17, N.Y.

Printed in U.S.A.
ASA½M954

Price, 25 Cents

American Standard

Television Picture Area—35mm Motion-Picture Film

ASA Reg. U.S. Pat. Office

PH22.95-1954

*UDC 778.5.621.397.5

1. Scope

1.1 The area to be included in a television picture is determined at the point of origination of the program concerned. In subsequent treatment of the resulting picture, it is very important that excessive cropping of the edges of the picture be avoided. The purpose of this standard is to establish operating procedures which will minimize the loss in area sustained in recording a television picture on 35mm film and in subsequently reproducing the film with a television film chain, and also to prevent the televising of a black or white band formed by the edge of the recorded area or the projector aperture.

1.2 Since the film chain equipment will also be used, without intervening readjustment of the equipment, for reproduction of films produced by standard photographic techniques, this standard provides for optimum utilization of the picture area of standard 35mm motion-picture film.

1.3 Film prepared by conventional photographic techniques for television reproduction shall be prepared in accord with the provisions of American Standard Aperture for 35mm Sound Motion-Picture Cameras, PH22.59–1954, or the latest revision thereof approved by the American Standards Association, Incorporated, which specifies the location and size of the camera aperture. The loss of significant picture information in television reproduction can be avoided by providing in the camera viewfinder an indication of the area to be scanned in television reproduction.

1.4 Paragraph 2 of this standard applies only to video recordings intended for reproduction by a television system. If the video recording is intended for direct projection to a theater screen the image dimensions, with the exception of picture width, are adequately specified by American Standard PH22.59–1954, or the latest revision thereof. For the correct aspect ratio the image width should be 0.841 ± 0.004 inch.

2. Video Recording on 35mm Motion-Picture Film

2.1 The picture aperture of a 35mm television recording camera shall be in accord with American Standard PH22.59–1954, or the latest revision thereof.

2.2 The television picture appearing on the picture tube of the video recording equipment shall produce an image on the recording film having a height of 0.612 ± 0.004 inch and a width of 0.816 ± 0.004 inch.

2.3 The center point of the image shall coincide with the center point of the picture aperture of a 35mm motion-picture projector as specified by American Standard Aperture for 35mm Sound Motion-Picture Projectors, PH22.58–1954, or the latest revision thereof approved by the American Standards Asso-

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Price, 25 Cents

American Standard

Television Picture Area—16mm Motion-Picture Film

ASA Reg. U.S. Pat. Office

PH22.96-1954

*UDC 778.5.621.397.5

1. Scope

1.1 The area to be included in a television picture is determined at the point of origination of the program concerned. In subsequent treatment of the resulting picture, it is very important that excessive cropping of the edges of the picture be avoided. The purpose of this standard is to establish operating procedures which will minimize the loss in area sustained in recording a television picture on 16mm film and in subsequently reproducing the film with a television film chain, and also to prevent the televising of a black or white band formed by the edge of the recorded area or the projector aperture.

1.2 Since the film chain equipment will also be used, without intervening readjustment of the equipment, for reproduction of films produced by standard photographic techniques, this standard provides for optimum utilization of the picture area of standard 16mm motion-picture film.

1.3 Film prepared by conventional photographic techniques for television reproduction shall be prepared in accord with the provisions of American Standard Location and Size of Picture Aperture of 16mm Motion Picture Cameras, Z22.7–1950, or the latest revision thereof approved by the American Standards Association, Incorporated, which specifies the location and size of the camera aperture. The loss of significant picture information in television reproduction can be avoided by providing in the camera viewfinder an indication of the area to be scanned in television reproduction.

1.4 Paragraph 2 of this standard applies only to video recordings intended for reproduction by a television system. If the video recording is intended for direct projection to a theater screen, the image dimensions are adequately specified by American Standard Z22.7–1950, or the latest revision thereof.

2. Video Recording on 16mm Motion-Picture Film

2.1 The picture aperture of a 16mm television recording camera shall be in accord with American Standard Z22.7–1950, or the latest revision thereof.

2.2 The television picture appearing on the picture tube of the video recording equipment shall produce an image on the recording film having a height of 0.285 ± 0.002 inch and a width of 0.380 ± 0.002 inch.

2.3 The center point of the image shall coincide with the center point of the picture aperture of a 16mm motion-picture camera as specified by American Standard Z22.7–1950, or the latest revision thereof. (This actually serves to locate the image relative to the film.)

3. Television Reproduction of 16mm Motion-Picture Film

3.1 The picture aperture of a 16mm television projector shall be in accord with American Standard Location and Size of Picture Aperture of 16mm Motion Picture Projectors, Z22.8–1950, or the latest revision thereof approved by the American Standards Association, Incorporated.

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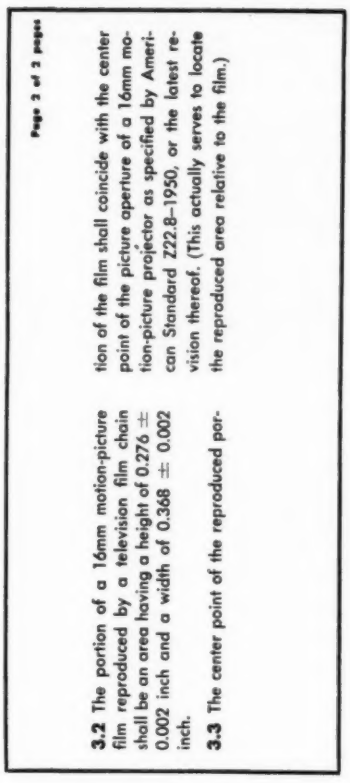
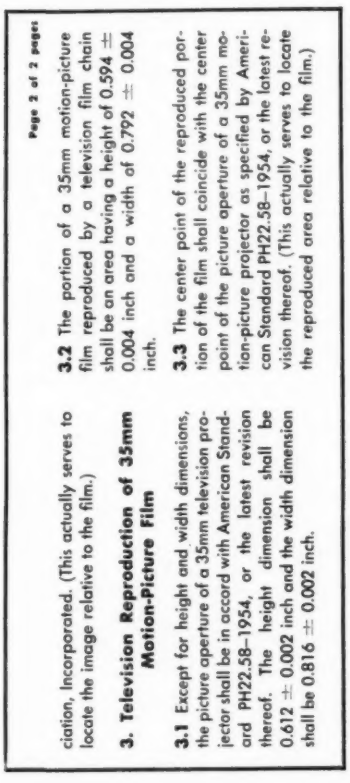


Page 2 of 2 pages

3.2 The portion of a 16mm motion-picture film reproduced by a television film chain shall be an area having a height of 0.276 ± 0.002 inch and a width of 0.368 ± 0.002 inch.

3.3 The center point of the reproduced portion of the film shall coincide with the center point of the picture aperture of a 16mm motion-picture projector as specified by American Standard Z22.8–1950, or the latest revision thereof. (This actually serves to locate the reproduced area relative to the film.)

PH22.96-1954



Page 2 of 2 pages

ciation, Incorporated. (This actually serves to locate the image relative to the film.)

3. Television Reproduction of 35mm Motion-Picture Film

3.1 Except for height and width dimensions, the picture aperture of a 35mm television projector shall be in accord with American Standard PH22.58–1954, or the latest revision thereof. The height dimension shall be 0.612 ± 0.002 inch and the width dimension shall be 0.816 ± 0.002 inch.

3.2 The portion of a 35mm motion-picture film reproduced by a television film chain shall be an area having a height of 0.594 ± 0.004 inch and a width of 0.792 ± 0.004 inch.

3.3 The center point of the reproduced portion of the film shall coincide with the center point of the picture aperture of a 35mm motion-picture projector as specified by American Standard PH22.58–1954, or the latest revision thereof. (This actually serves to locate the reproduced area relative to the film.)

PH22.95-1954

News and Reports

SMPTE 76th Convention Local Arrangements

The roster of chairmen who will put on the Fall Convention has been released by Convention Vice-President Servies:

Local Arrangements Chairman,
Philip G. Caldwell
Registration, Robert P. Young
Hotel Arrangements, Vaughn C. Shaner
Transportation, Betty Hartlane
Projection, Bundy Smith
Public Address, Edwin W. Templin
Hospitality, Jack Duvall
Exhibits, Thomas J. Gibbons, Jr.
Publicity, Harold Desfor, Martin Waldman
Ladies Committee,
Mrs. P. G. Caldwell, Mrs. J. G. Frayne
Luncheon, Carl Hunt
Banquet, Sidney Solow

The Advance Announcement of the Technical Program was mailed to all members on September 1, with a hotel reservation form enclosed. The rates and reservation offices for The Ambassador were also published on page 67 of the August *Journal*. The Tentative Program, as arranged by Program Chairman Lovell and the Papers Committee, is given in later pages of this *Journal*.

Tom Gibbons, Exhibit Chairman, has sent layouts of the exhibit space and booths to the industry's equipment and services suppliers, and a large exhibit is now guaranteed.

The traditional banquet, at which Society awards will be made, will be held on Wednesday evening, October 20.

Society News

The items of news and official business that appear below will be of interest to members who follow Society affairs.

Board Meeting

The Board of Governors met for the third time this year, on July 15, in New York City. Twelve of twenty-four members attended, with Herbert Barnett presiding.

First item on the agenda was the report by the Executive Secretary who told briefly what the Society had accomplished during the first six months of 1954 and how its financial affairs stood at the close of business on June 30. He recalled that, to meet an expected reduction of income for 1954, the balanced budget adopted at the beginning of the year and the activities that that budget provided for had been scaled down to a level well below that of 1953. Test films aside, the reduction amounted to about 20%.

Tight limits had been set on the *Journal*, pages per issue being cut almost 40%. Late in January the headquarters staff was reduced by one and in March another staff member went onto a half-time schedule. Membership solicitation funds were cut by 35% while provision for administrative expenses was reduced by about 17% below actual expenditures in this category for 1953.

Careful supervision of operations during the first and second quarters of this year had kept expenses within the bounds set by the Society's 1954 budget. Income had not held up, however, and by the end of May had fallen behind far enough to show clearly that the second-half budget, which is a mid-year revision, had to provide for some additional savings to insure that actual operations, come year-end, will not have violated the Board's firm request that 1954 finish up well in the black.

In view of the deficit for last year, which was reported on page 315 of the April 1954 *Journal*, it is vital that the Society not be forced to draw again on its modest reserve.

While work was proceeding on the new and tighter budget, several economy measures clearly necessary were taken under the authority of the Executive Committee. The position of headquarters Office Manager was discontinued effective July 1. The one half-time employee was discharged and another placed on half-time schedule. Also effective July 1 was a 30% rent reduction, occasioned by the move of headquarters from the American Radiator and Standard Sanitary Building at 40 West 40 Street to the Bryant Park Building at 55 West 42 Street, New York City.

Based on the fact that actual income for the first six months had run 25% lower than the initial budget estimate and upon the detailed knowledge of actual second-half experience for several prior years, income for the full year was estimated at $213,625, which is below the original 1954 budget by 12% or $29,000. Using this as a starting point, the Executive Secretary and the Executive Committee prepared the budget revision matching the anticipated loss of income with a $27,540 or 12% cut in provision for expenses. This reduction was the largest that the budget planners felt could be made without critically compromising or dropping entirely, any of the basic services.

Of the savings planned, these significant ones came about in this way: 30% reduction in test film operations; 25% cut in membership expenses; a 2½% reduction in publications operations which were already at a low figure. Administrative expenses were trimmed by 6%.

In practical terms these changes mean that the members themselves must take over almost completely the procurement of convention papers, the planning and operation of semiannual conventions, solicitation of sustaining and individual members and, on occasion, the preparation of publicity material and the recording of meeting minutes. The headquarters, operating on the new basis, is prepared to provide only those services which it is impractical, for one reason or another, for the members to provide for themselves.

Reviewing the operating policies and the strict control adopted during the past two years, Mr. Kreuzer, Financial Vice President, explained that the new second-half budget for 1954 was the direct result of close control and that these efforts would bring the Society out nicely in the black at the end of the year without affecting, in any major way, the extent or value of the

services that have become the traditional obligations of SMPTE. On his recommendation the Board adopted the proposed new budget.

Through the month of June, 451 new members joined the Society and 28 former members were reinstated. Although well behind the record of 596 new members and 31 reinstatements for the first half of 1953, this year's growth still presents a very attractive picture.

Having considered on many occasions the balance between the Society's income in the form of dues from individual members and the cost of providing those members with the Journal, conventions, Section programs, and other services, the Board of Governors finally and reluctantly concluded that the quality and extent of such services could be continued over the years with assurance only on condition that the rate of annual member dues was increased, and that the increase take effect with the calendar year 1955. Although the value of the dollar has changed by a considerable amount in recent years, membership dues have remained the same since 1946, when Associate dues increased from $7.50 to $10 and Student dues went up from $3 to $5.

During its previous meeting in May, the Board discussed this question in detail and passed a resolution proposing such an increase and subject to ratification, at this meeting. The question was again considered in July and after extensive discussion, the Board of Governors passed these three formal resolutions:

"*RESOLVED*, that in order adequately to carry out the objects of the Society as set forth in its Constitution and Bylaws, it is necessary to increase annual dues rates as follows: Associate from $10 to $12; Active and Fellow from $15 to $18;" and it is further—

"*RESOLVED*, that the Secretary be and is hereby directed to announce this recommendation to the membership by a notice in the earliest available Journal," and it is further—

"*RESOLVED*, that the Secretary be and is hereby directed to place on the agenda for the next annual meeting of the Society, a proposal to so amend the Bylaws of the Society."

The Treasurer, Secretary and the Vice-Presidents reported on the areas of Society activity for which they are responsible. Mr. Colburn, Treasurer, presented the cash report; Mr. Simmons' Editorial Vice-President, reported, in absentia, that progress with the Journal's advertising program had proved somewhat better than anticipated, that the new Journal in $8\frac{1}{4}$" × $11\frac{1}{4}$" size would prove to be an attractive and efficient one and that the advertising policy adopted by the Board and to be observed explicitly in the acceptance of advertising copy would make that section of the Journal a useful service to the members.

Mr. Jensen, Engineering Vice-President, explained that the committee on Films for Television and Television Film Equipment had been combined because of their gradually overlapping interest, into a single television committee under Mr. Gentry Veal as Chairman. Established relations with the television committee work of the Radio Electronics-Television Manufacturers' Association will continue as before. High on the list of current projects is development of color test films and test slides for use by television broadcasters.

The eleven technical committee meetings held during the 75th Convention and the fifteen to twenty additional standards expected to develop from that work were, Mr. Jensen pointed out, an indication of the current volume of SMPTE standardization activity. Members of all engineering committees had, by the time of the Board meeting, received copies of a new engineering committee manual that had been prepared by Hank Kogel as a guide for chairmen and for newcomers to the SMPTE engineering committee organization.

Jack Servies, Convention Vice-President, reported that the 75th Convention in Washington had come out in the black, and that work already underway for the 76th Convention in Los Angeles forecast a successful operation there.

Mr. Seeley, Secretary, presented to the Board the reports of the Committee on Fellow Membership, Sarnoff Award, Warner Award and Progress Medal, and in the sphere of his own major current project explained that work on the new series of Administrative Practices was progressing.

Chairman of the Nominating Committee, Garland C. Misener, offered for Board consideration, the names of candidates selected by his committee, to appear on the national election ballot. The slate of candidates for the Society's 1954 national election is as follows:

President	John G. Frayne
Executive Vice-President	Barton Kreuzer
Editorial Vice-President	Norwood L. Simmons
Convention Vice-President	Byron Roudabush
Secretary	Edward S. Seeley
Governors from East Coast Area	(*nominees*) Gordon A. Chambers Russell C. Holslag George Lewin Reeve O. Strock
Governors from Central Area	(*nominees*) Arthur J. Hatch, Jr. Bruce Howard W. Wallace Lozier Malcolm G. Townsley
Governors from West Coast Area	(*nominees*) Don M. Alexander John W. DuVall Lloyd T. Goldsmith Sidney P. Solow

Jim Wassell presented the Central Section's treasury balance and the names of Section nominees for the 1954 election. These were:

Chairman	James L. Wassell
Secretary-Treasurer	Kenneth M. Mason
Managers	(*nominees*) Jerome C. Diebold Milton Goldstein L. S. P. Hancheck Robert G. Herbst Gerhard W. Kugel David W. Ridgway

Everett Miller presented the report of the Atlantic Coast Section. Following is a list of that Section's nominees for the 1954 election:

Chairman	Everett Miller
Secretary-Treasurer	George H. Gordon
Managers	(*nominees*) William H. Deacy, Jr. Paul A. Kaufman Karl N. MacIlvain Barton F. Perry Victor M. Salter Samuel L. Silverman

Subsequent to the meeting, a report from Phil Caldwell, Pacific Coast Section Chairman, offered the following list of nominees:

Chairman	Philip G. Caldwell
Secretary-Treasurer	Edwin W. Templin
Managers	(*nominees*) Harlan Baumbach E. E. Benham Lester H. Bowman Karl Freund Robert G. Hufford

Notice of Annual Meeting

Attention of all voting members of the Society, all members in the Active, Fellow and Honorary grades, is invited to this official notice that the Society's annual meeting for 1954 will be held at 3:00 p.m. on Monday, October 18, at the Ambassador Hotel in Los Angeles. The meeting will take place directly following adjournment of the Get-Together Luncheon and immediately preceding the first technical session.

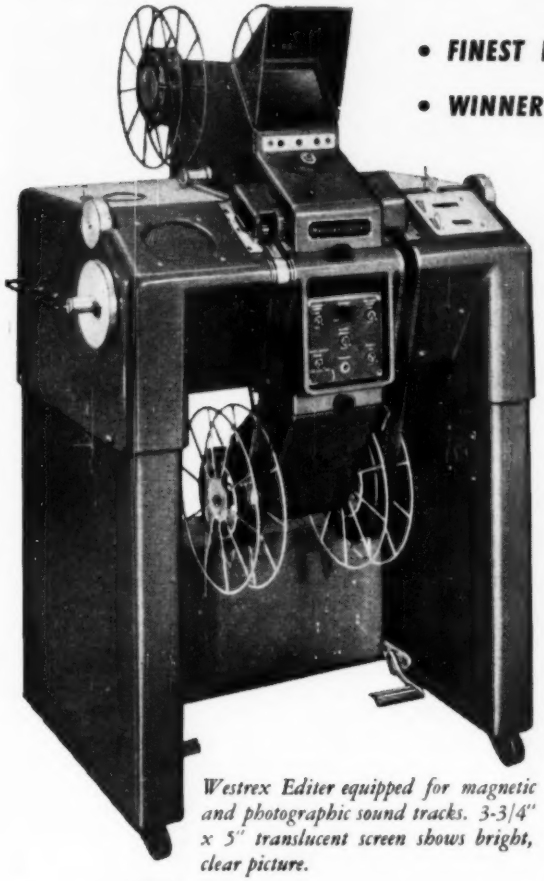
The main item on the agenda concerns a vote to accept or reject a proposal to increase the rates of dues for individual membership in the Society.

As the opening paragraphs of the Board meeting report that immediately precedes this annual meeting notice indicate, the Board of Governors has given careful and extended attention to financial planning and to the conduct of the internal affairs of the Society. Continuing efforts to operate the Society with prudence and economy had, for some time, offset the gradual rise in costs of doing business. It is now apparent that two additional and specific measures, one to distribute a portion of the administrative workload among the members themselves and the other to increase the Society's annual income, have become necessary. The first is being done. To accomplish the second, the Board has taken several steps among which is the proposal that the rates of individual membership dues in the grades of Associate, Active and Fellow, be increased effective with the calendar year 1955. This seems to be the only feasible way for the Board of Governors to insure not only the continuous and effective growth of SMPTE but that each Society member receives each year a full complement of the services that his organization was created to provide.

The Board proposes that dues for Fellows and Active members be increased from $15 to $18 per year, that dues for Associate members be increased from $10 to $12 per year. There is no proposal at

Westrex Editer

- **FINEST FILM EDITING MACHINE FOR STUDIOS EVERYWHERE**
- **WINNER OF AN ACADEMY AWARD FOR SCIENTIFIC OR TECHNICAL ACHIEVEMENT**



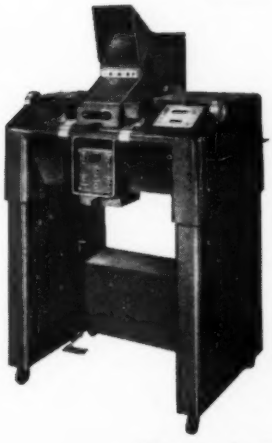
Westrex Editer equipped for magnetic and photographic sound tracks. 3-3/4" x 5" translucent screen shows bright, clear picture.

Designed and engineered by the Westrex Hollywood Laboratories — in cooperation with leading studios — the new Westrex Editer is an advanced machine that meets every film editing need.

The Westrex Editer can handle both standard and the new small-hole perforated 35mm films — film strips — motion picture films — magnetic or photographic sound films (single or multiple) — composite release prints — and for the first time it makes possible "projection viewing" of an enlarged image on a wall or screen without extra attachments.

The Westrex Editer is quiet in operation — no intermittent, hence less noise and less film damage — speedy and efficient. Among its advanced features are simplified threading — automatic fast stop — synchronization while running — improved sound — lower flutter.

The Westrex Editer — available in 35mm model — is the latest in a long line of notable Westrex contributions to the motion picture industry. A new illustrated folder that describes in detail its many technical and operating advantages is yours for the asking.



The basic Westrex Editer, for use with film strips — vertical film handling method — faster and more practical.

The Westrex Editer features "projection viewing" on wall or screen without disturbing the adjustments of the normal optical system.

Research, Distribution and Service for the Motion Picture Industry

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FORMERLY WESTERN ELECTRIC EXPORT CORPORATION

present for an increase of dues for student members.

Since the rates of dues are defined under By-law IX, an amendment to that bylaw is required. The first essential step toward such an amendment was the resolution of the Board of Governors quoted in full above. The second essential step toward such an amendment is satisfied by publication of this notice of the 1954 Annual Meeting and its purposes.

The third step will be a "show-of-hands" vote by the voting members of the Society of whom a quorum must be present on whether to approve or disapprove the recommendation of the Board.

The Bylaws provide that in the event a quorum (at the present time 120 voting members) is not present at that meeting, an affirmative vote of three-quarters of the entire membership of the Board of Governors may make that proposal part of the Bylaws. All members of the Board of Governors have been notified in writing that in the event a quorum of the voting membership is not present at the Annual Meeting, a special meeting of the Board of Governors will be called at noon on Tuesday, October 19.—*B.N.*

The New Journal

When the Board of Governors decided that advertising would be published in the *Journal* beginning in July, it was also decreed that the *Journal* be in a new format to accommodate advertising plates of the standard 7 × 10 in. size. This change was practical not only for advertising but also for the *Journal* throughout, allowing the use of standard material in making up pages, standard lockup of forms for press and standard paper.

The *Journal* is issued in the 8¼ × 11¼ in. size because that works out of a standard sheet of paper and allows maximum printing efficiency. This size is preferred by the Society's printer who also produces *Electrical Engineering* and other journals in this size.

Within the overall text page size of 7 × 10 in., the type face, type size and column width have been repeated from the old *Journal* as the most practical choices for economy and readability. Another physical aspect, the cover, was for this six months kept similar to the recent cover for the sake of continuing identity.

And inside, too, as far as substance goes the policy is to keep the *Journal* the same, except for including advertisements. The technical papers are to be of the same type and will continue to be just as rigorously screened by the same Board of Editors. Each technical paper is to be paged in successive pages, without "continued's" into the back of the *Journal*. News, reports and reviews will appear throughout the advertising section.

The new *Journal* carries 206% as many words per page as the previous format. This is the most efficient and economical format for the *Journal* up to this time.

Changes in format and procedures, in the past five years, and tightening up on authors alterations and photoengraving costs have kept the overall *Journal* cost increase at 16% while unavoidable increases in printing and paper costs for all publications of this kind have increased by 35%.

The present method of binding, along with the new format will yield considerable further gains in overall *Journal* efficiency.

—*V.A.*

On a recent trip around the world, Dr. John G. Frayne, SMPTE Executive Vice-President, found evidence of Society activities at almost every place he visited. Most notable, however, was Hong Kong where the dynamic Harry More, Westrex Hong Kong Branch Manager, with all four of SMPTE's Hong Kong members, greeted him on arrival at the airport. Later our Executive Vice-President was the guest of Harry More and his SMPTE associates at a special Chinese dinner, Cantonese style. At a reception given for our peripatetic Vice-President, in which SMPTE and Westrex Corporation shared honors, the above picture shows Dr. Frayne along with the Hong Kong members. They are from left to right, William C. K. Hu, Managing Director of Wader Studio; John G. Frayne; Harry More, Westrex Hong Kong Branch Manager; Robert Chung, Eastman Kodak Co., Hong Kong; and Walter Wu, an expert of film processing. Incidentally, Walter Wu spent about a year in Hollywood working in various film laboratories. Dr. Frayne's trip by air continued with stops in India and Ceylon and generally throughout Europe to reach a peak tempo at Washington, D.C., during the Society's Spring Convention. He found an intense interest in SMPTE activity in India where there appears to be a great thirst for technical knowledge and a great desire for many people to join the Society. There is no doubt that this organization is the leading one throughout the world in its field, and its *Journal* is regarded by all as having the last word on advances in the motion-picture and television arts.

Alex Quiroga, Senior Light Direction Engineer at the Hollywood studios of the American Broadcasting Co., has been awarded the 1954–55 WAAM Television graduate fellowship at Johns Hopkins University. The annual fellowship was established by the Baltimore television station WAAM at Johns Hopkins in 1952 to give a television professional man one year for special studies of value to his own development and to the industry.

Mr. Quiroga, the third person to hold the fellowship, will spend his year working on color television at a graduate level in the departments of physics, psychology and astrophysics. Since joining ABC-TV in 1949 as a cameramen, Mr. Quiroga has entered the field of research in video recording and created optical devices to improve the production values of TV programs, including the "Quirogascope" for titling or rotating a scene by optical means during an actual telecast.

Book Reviews

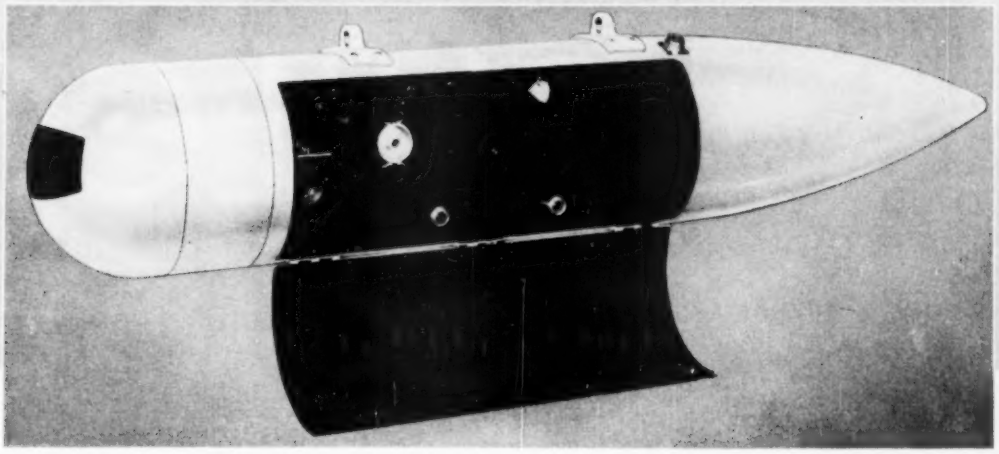
Flash! Ultra-High Speed Photography, 2d ed.

By Harold E. Edgerton and James R. Killian, Jr. Published (1954) by Charles T. Branford Co., 551 Boylston St., Boston 16. 215 pp. Profusely illus., incl. 3 color plates. 8¼ × 11 in. $6.50.

Nearly everyone who has had anything to do with the ever-popular "Strobe-light" has at one time or another looked into *Flash*, long one of the best illustrated books showing what electronic flash can do in expert hands. Now comes a second edition of this "picture" book pertaining to that branch of photography which uses the gas-discharge tube as a primary light source.

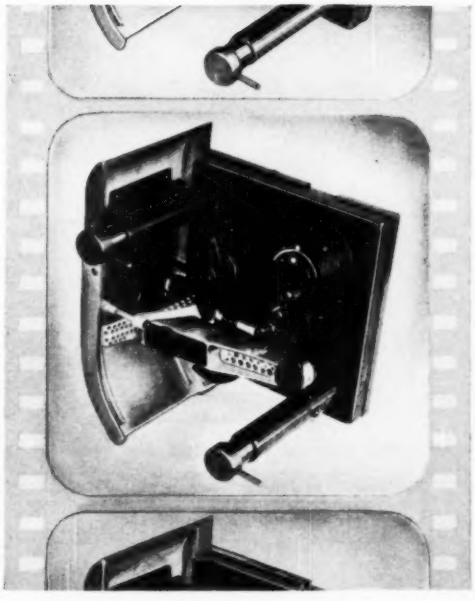
One is impressed even overwhelmed, by the multitude of subject matter, ranging from color portraiture to graphic analysis of machine operations. As a very broad and general outline of possible uses of electronic flash, this book fulfills a basic need—that of popularization and education. It does not, however, offer much information to the technical worker in the field of photographic analysis.

PHOTO-SONICS INC.



70MM-5A AIRCRAFT CAMERA

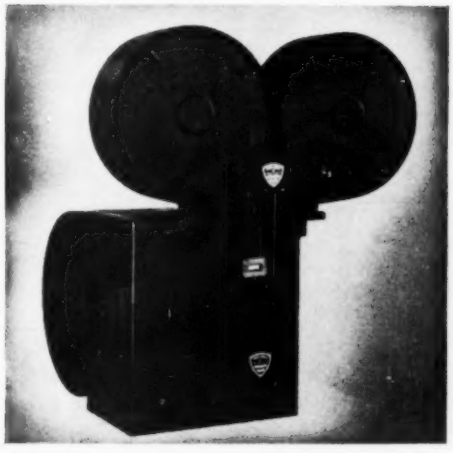
Aperture Size 1.156 x 2.25 inches—400 ft. film capacity
Film registration pins—60 frames per sec.
150 watt heater—24 volt motor



Actual frame size 70mm-10A showing photograph of film movement

70MM-10A CAMERA

Aperture Size 2.25 x 2.25 inches
Film registration pins
60 frames per second
110 volt synchronous motor
Film load—1000 or 400 ft. mag.



Additional information on request

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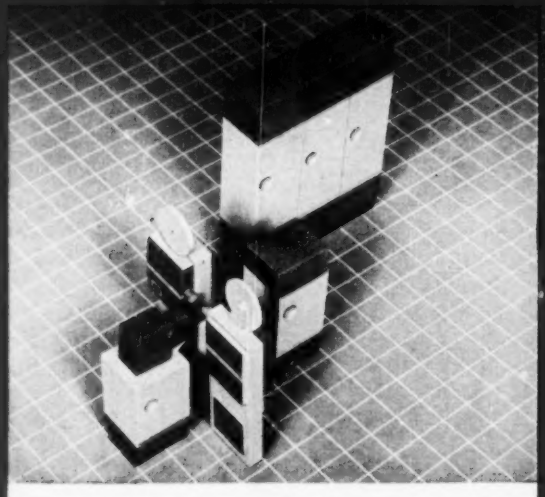
This Philco 16mm CineScanner and its companion, the 35mm model, provide the finest film reproduction in either color or monochrome.



Multiplexed arrangement of two 16mm CineScanner film units and automatic dual slide changer for four program sources in color.

CineScanner—superior for monochrome

. . . the only practical method for color!

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CineScanner

and enjoy modern film telecasting!

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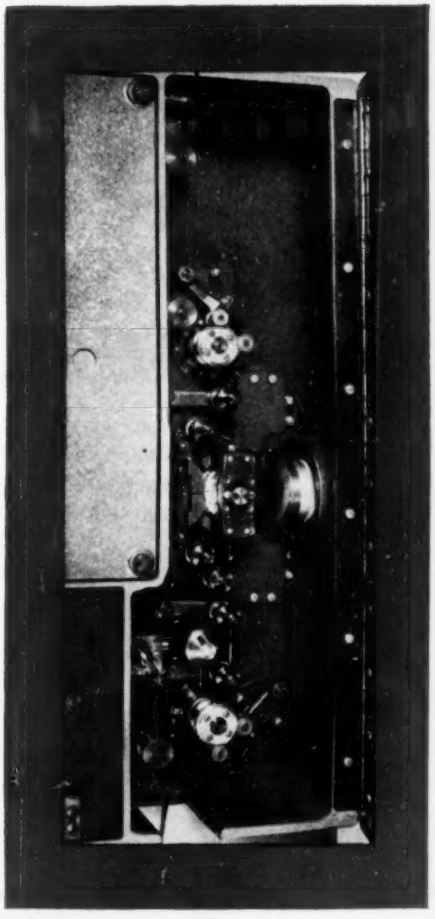
- **Preview of all Program Sources**
- **Color and Monochrome, 16MM and 35MM Models**

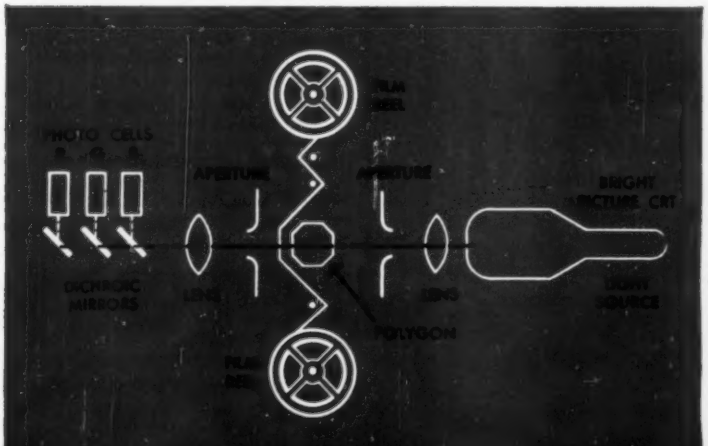
Once you've seen CineScanner operate—witnessed the clear, steady pictures and observed the smooth, silent performance—you will agree it's the only way to televise film—*in monochrome or color!*

There are good technical reasons why: The Philco CineScanner employs flying-spot scanning, a technique never equaled in producing high definition pictures. In CineScanner, there's no hot projection lamp to fail or burn the film. Only source of light is a long life, cathode-ray tube with dependable "cold" light harmless to film. CineScanner employs a special continuous-motion film transport mechanism designed by Philco and built by the Mitchell Camera Corporation of Hollywood . . . no noisy, film-damaging intermittents in the CineScanner! Most important of all to color Broadcasters, CineScanner uses economical photo tubes instead of expensive camera tubes . . . *and there are no color registration problems in CineScanner!*

With the Philco CineScanner, you can start today in monochrome, convert tomorrow to color—with no obsolescence of equipment! Get full technical data on this new and greatly improved method of televising films and slides. Contact Philco, Dept. SE today.



Interior view of the film unit showing precision film transport mechanism, sound head and the simplicity of the optical system.



Simplified diagram showing the basic principles of CineScanner operation.

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The second edition of *Flash* differs from the original in several respects. Some new pictures have been added, including three examples of color photography. A new technical section has been included. This section is very good, but does not suffice for the engineer, while it is probably too advanced and specialized for many pictorial photographers. There are interesting chapters on the assessment of flashtube characteristics, as well as the design of electronic flash equipment. A bibliography and a list of equipment manufacturers has been included.

The entire volume has been printed on coated stock. Reproduction and printing is generally good considering the difficult subject matter. Some pictures, however, show defects particularly in heavily inked areas.—*Kenneth Morgan*, Research Laboratories, Interchemical Corp., 432 W. 45 St., New York 36.

L'Arc Electrique Intensif

By Dr. Jean Parisot. Published (1950) by Gauthiers-Villars, Quai des Grands-Augustins 55, Paris (6). 11 × 116 pp. 48 figures and plates incl. 6 tables: 9 × 11 in. Price $3.56.

The author is head of the research laboratory of "La Société Carbone-Lorraine" and much of his material is taken from their hitherto unpublished work. He first traces the historical development of the high-intensity arc from the earlier flame and projector carbons, emphasizing its distinguishing features. A short section on materials and methods of carbon manufacture is included, together with a rather detailed description of lamp operation with several different types of high-intensity carbons.

A section on light measurement describes in considerable detail the procedures used in his laboratory for measuring light output, including brightness distribution over the crater surface and spectral-energy distribution of the light. Typical curves of both are included.

The processes going on at the positive and negative electrodes while the arc is operating are analyzed, emphasizing the fact that light intensity is determined by the positive carbon, while the negative carbon can affect steadiness. The discussion of the effects of carbon composition on performance includes a chapter on the use of substances other than the cerium rare earths as flame materials or "mineralizants." This knowledge permitted France to keep its motion-picture theaters in operation when the country was deprived of rare earths during the German occupation.

A review of the theories proposed in order to account for the high brightness obtainable from this source leads the author to conclude that the subject calls for considerably more work.

The book can be recommended as combining in one volume the practical and theoretical aspects of operation of the high-intensity arc. Its principal weakness is inadequate treatment of means for increasing crater brightness.—*C. E. Greider*, National Carbon Research Laboratories, P.O. Box 6087, Cleveland 1.

Hunt Chemicals for both
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FOR TECHNICAL SERVICE WRITE TO:
CHARLES F. LO BALBO, *Motion Picture Technical Advisor*

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Without exception, ALL film should be treated, if you are to get maximum results in terms of good projection and number of showings. Without treatment, your film—from initial release to the last booking—is much more susceptible to damage. And damaged film can result in an indifferent audience.

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Shrinkage Reduction
Scratch Removal
Rehumidification
Cleaning and Repairs

Film Library Servicing
Shipments, Inspection, Cleaning, Repairs, Inventory and Booking Records, Storage

Servicing TV Shows on Film
Insertion of Commercials, Shipments to Stations, Booking Records, Follow-up, Inspection on Return, Cleaning, Repairs, Replacements, Storage, Substitution of Commercials, Reshipments

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ADVANCE PROGRAM

The advance notice, with hotel reservation form, was mailed to the membership on September 1. The Advance Program below is the last advice about the Convention — until registrants get their Final Programs at the Registration Desk.

SMPTE 76th Convention October 18–22 — Los Angeles

Convention Exhibit of industry equipment is in The Ambassador, as are the technical sessions and entertainment events, unless otherwise noted.

SUNDAY OCTOBER 17

Registration for the Convention will be opened in the afternoon in the Ambassador Hotel Lobby.

MONDAY OCTOBER 18

9:30 A.M. Registration, Ambassador Hotel Lobby

12:30 P.M. Get-Together Luncheon, The Cocoanut Grove; Guest Speaker

3:00 P.M. Annual Business Meeting of the Society

3:30 P.M. Color Television, Ambassador Theatre

Recording Color Television Signals

E. DUDLEY GOODALE, *National Broadcasting Company, New York*

This paper will describe a method of recording color television signals utilizing standard motion-picture color films. A brief description of the equipment and techniques employed in conjunction with experimental recordings at NBC will be given together with a short demonstration reel of the results obtained to date.

Multi-Channel Television Relay Station

GEORGE R. SUTHERLEN, *U.S. Naval Ordnance Test Station, China Lake, Calif.*

Completely described are all aspects of the authorization, selection of site, building, power, selection of equipments and the operation of the 7-channel television relay station on Laurel Mountain, Calif. Described is the technique which all 7 Mount Wilson television signals are relayed from the top of Laurel Mountain to Indian Wells Valley and a population of 15,000 people.

Test Instruments for Color Television Broadcasting

JOHN W. MILLION, Jr., and ROBERT K. HUNSICKER, *Wickes Engineering and Construction Co., Camden, N. J.*

Test instruments for broadcast use, such as the Amplitude Linearity Tester, the Multi-Burst Generator, the Vector Display Equipment and the Envelope Delay Tracer, have come into their own as a result of color television. The evolution of these instruments and their application in making amplitude, linearity, frequency and phase response tests of studio, distribution and transmitting equipment will be discussed in this paper. Special emphasis is placed on the "monitor" types of equipment that enable the operating personnel to make rapid checks of equipment performance, rather than on the "laboratory" or "measurement" types, which usually require a higher degree of operational skill and more time than is available.

8:15 P.M. Color Television Session. CBS Television City. Description and Tour, Including Color-Film Reproducing Equipment.

TUESDAY OCTOBER 19

9:30 A.M. Field Trip to NBC Television Studios

2:00 P.M. Television Session, Ambassador Theatre

A Short History of Television Recording

ALBERT ABRAMSON, *CBS Television Technician, Hollywood, Calif.*

This brief survey of the development of television recording since 1927 covers the evolution of the three basic television recording processes: stylus, magnetic and photographic. The film recording systems used in the United States and Great Britain are briefly described. The introduction of television recordings made on magnetic material in both monochrome and color is noted. The paper concludes with a short resume on the new art of electronic motion pictures produced with television cameras and recording facilities.

Equipment for Evaluating Lenses of Television Systems

E. HUTTO, Jr., *Engineering Products Div., Radio Corp. of America, Camden, N. J.*

A lens bench has been developed incorporating a nodal slide and a flat field indicator which permits the rapid determination of the square wave flux of a lens both on and off axis. A synchronously driven test object is used, and a plot of response versus line number is presented on an oscilloscope. Lenses up to 24 in. in focal length and 3¾ in. in diameter may be tested.

Continuous Projector Problems

O. WITTEL and D. HAEFELE, *Eastman Kodak Co., Rochester, N.Y.*

The problems of getting good vertical image steadiness in a continuous projector for television of the type which uses an optical compensator consisting of rotating and tilting mirrors are described.

A 16mm Projector for Operation with a Television Film Chain on a Partial Storage Basis

EDWIN C. FRITTS, *Camera Works, Eastman Kodak Co., Rochester, N.Y.*

The modification of a projector in current use with full-storage operation into an iconoscope is described. An accelerating quill rotating at 720 rpm, intermediate between an 1800 rpm motor and the intermittent sprocket, provides the change in phasing to place all pulldown action in the same position in the television fields Linkage between the motor and quill and the quill and intermittent are timing belts. The design is such that change of present equipment may easily be made in the field.

8:00 P.M. Color Television Session, Academy Award Theatre

Color Film Equipment

A. C. LUTHER, *Radio Corp. of America, Camden*

Color Television Projection Equipment

L. L. EVANS, *Radio Corp. of America, Camden, N.J.*

Large-screen color television has been demonstrated several times and commercial equipment is available. Various problems of colorimetry, optics and electronics have been overcome and the resultant picture is adequate for theater use. The technical features of the equipment are outlined as well as application information. The projector described will produce a picture 15 ft by 20 ft with good highlight brightness. It operates on the standards formulated by the National Television System Committee which have been adopted for general use by the FCC.

Some Laboratory Procedures in Preparing Television Prints in Black-and-white and Color from Eastman Color Negative

SIDNEY P. SOLOW and EDWARD H. REICHARD, *Consolidated Film Industries, Hollywood, Calif.*

Many telefilm producers are preparing for color television broadcasting by shooting in 35mm Eastman color, releasing for current requirements in 35mm and 16mm black-and-white, and storing the color original for future use. Various basic laboratory techniques for making panchromatic black-and-white prints for projection and duplication are described. Methods are detailed for incorporating lap dissolves and fades without additional dupe generations in both black-and-white and color versions. Shown also are alternative paths for arriving at 16mm color release prints including utilization of the new Eastman color 16mm color positive material.

WEDNESDAY OCTOBER 20

10:00 A.M. Magnetic Sound for Television Films, Ambassador Theatre

Discussion of the factors pertinent to obtaining magnetic-stripe soundtracks on television films, both 16 mm and 35 mm.

2:00 P.M. Magnetic Recording Session, Ambassador Theatre

An Electronic Comparator for the Automatic Inspection of Magnetic Sound Prints

JEROME W. STAFFORD, *Sound Dept., Metro-Goldwyn-Mayer Pictures, Culver City, Calif.*

This paper describes an electronic system for comparing magnetic sound prints with the master track during the printing operation. In the release printing of CinemaScope pictures the comparator is a useful tool for the automatic inspection of the product.

Magnetic Head Wear Investigation

M. RETTINGER, *Radio Corp. of America, Hollywood, Calif.*

For a given film and film wrap angle, magnetic head life is proportional to the film pressure on the head produced by the film tension, the square root of the core radius, the 3/2 power of the pole face depth, the core width, and, in some undetermined manner, the core hardness. More briefly, one may say that (for a constant film and film wrap angle) head life is proportional to the film pressure, volume of removable core material, and core hardness.

A Moving Coil Feedback Disk Recorder

C. C. DAVIS, *Westrex Corp., Hollywood, Calif.*

The distinctive feature of this recorder is the application of corrective feedback originating in the actual stylus driving mechanism. Thus, the motion of the stylus is accurately controlled, irrespective of recording conditions, over a wide range of amplitudes and frequencies. The latest improvements are described and include a simple method of applying heat to the stylus and the use of tapered shank styli to facilitate their replacement.

Report of Magnetic Recording Subcommittee

ELLIS W. D'ARCY, Chairman, *Ellis W. D'Arcy & Associates, Chicago*

Perceptibility of Flutter in Speech and Music

FRANK A. COMERCI, *Material Laboratory, Bureau of Ships, New York Naval Shipyard, Brooklyn, N.Y.*

The results of subjective rankings of various speech and music selections containing various amounts and types of flutter are presented. These rankings are compared to the type of flutter and the results of flutter measurements using peak and rms indications and various flutter rate weighting networks. The comparisons show that a meter using an rms indicating device and a flutter rate weighting network will provide flutter measurements which are directly related to the obnoxious quality that

1 Take-up reels
2 Feed reels
3 Splicing elevator (40 seconds capacity)
4 Exhaust fan motor (1800 cfm)
5 Feed bottles with bottom screw vents
6 Drying air thermometer
7 Micrometer stripe adjustments
8 Binocular microscope
9 Sapphire shoes beneath precision striping heads
10 Splicing block
11 Air heaters
12 295' leader
13 High temperature drying chamber (4 minutes)
14 Removable partition facilitates threading
15 Low temperature drying chamber (2 minutes)
16 Sliding glass doors

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... an entirely self-contained, semi-portable, one-man operated magnetic oxide striping machine, identical in every vital feature to the now famous 35-mm Soundcraft Magna-Striper which won the coveted 1953 Academy of Motion Picture Arts and Sciences Award.

... the same fine Soundcraft engineering and construction that every major Hollywood producer of CinemaScope has used to process stereophonic sound release prints.

With ease and precision this new equipment quickly applies two stripes of Soundcraft's perfected magnetic oxide to any 16-mm film ... black and white or color, single or double perforation. Jeweled bearing shoes (Item 9 above) assure precision striping even with old, warped or distorted film ... even when spliced and spliced and *spliced!* All wiring is explosion proof.

Write today for complete franchise information and full technical details about how you, too, can build a highly profitable business with this revolutionary new Model Z 16-mm Soundcraft Magna-Striper!

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the flutter imparts to music and speech. (This paper's presentation is subject to clearance by the Navy Dept.)

Development of a Method for Measuring the Magnetic Strength Existing on 16mm Magnetic Soundtrack

ROBERT SCHWARTZ, SHELDON I. WILPON and ROBERT A. COMERCI, *Material Laboratory, Bureau of Ships, New York Naval Shipyard, Brooklyn, N.Y.*

The Material Laboratory is in the process of developing a method for measuring the magnetic strength existing on 16mm magnetic soundtrack by utilizing a nonmagnetic loop for the determination of the absolute surface induction at 400 cycles/sec for "pegging" the relative surface induction vs. frequency characteristic obtained by the "short gap" or other approved method. This paper shows that this method was found to be a practical method for determining the surface induction recorded on presently available commercial 1¼-in. magnetic tapes, independent of the tape characteristics and the depth of penetration of the recorded signal. (This paper's presentation is subject to clearance by the Navy Dept.)

6:45 P.M. Cocktail Hour

8:00 P.M. Semiannual Banquet and Dance, Embassy Room (Informal, dress optional)

THURSDAY OCTOBER 21—CONCURRENT SESSIONS

9:30 A.M. High-Speed Photography Field Trip to Moody Institute of Science

10:00 A.M. Motion-Picture Equipment Session, Ambassador Theatre

A New Studio Zoomar for 35mm Motion Picture Work

FRANK G. BACK, *Zoomar, Inc., Glen Cove, L.I., N.Y.*

A new Zoomar lens, especially designed for 35mm motion picture work, will be demonstrated. It has a focal range from 40 mm to 120 mm and a speed of *f*/4. Compared to the old Zoomar-35 it is light (6 lb) and only 7½ in. long including a coupled, wide-vision viewfinder. This viewfinder is without eyepiece or peephole and therefore does not restrict the head movements of the cameraman. Performance of the new lens is so much better than that of the old Zoomar-35 that, even when wide open, its image quality comes very close to that of a good standard 35mm motion picture lens.

CinemaScope Camera Lenses

JOHN D. HAYES, *Bausch & Lomb Optical Co., Rochester, N.Y.*

The wide acceptance by the motion picture industry of the CinemaScope process of motion picture presentation created a pressing need for camera taking lenses of a variety of focal lengths. Described are the optical and mechanical aspects of the development of a series of lenses designed specifically to provide this needed choice.

An Exploration of New Methods for Splicing Film

D. C. CHAMBERS and W. R. HOLM, *Photo Products Dept., E. I. Du Pont de Nemours, Parlin, N.J.*

2:00 P.M. High-Speed Photography Colonial Room

Panel discussion of the program presented at the 2d International Symposium on High-Speed Photography held in Paris.

2:00 P.M. Motion-Picture Screens, Ambassador Theatre

A New Method of Describing and Measuring the Granularity of Photographic Materials

R. CLARK JONES, *Polaroid Corp., Cambridge, Mass.*

The new method employs a two-dimensional noise spectrum that is analogous to the one-dimensional noise spectrum used to describe the frequency distribution of electrical noise. The two-dimensional noise spectrum describes the size distribution of the density fluctuations that constitute the granularity. It is urged that the noise spectrum is *the* best way to describe granularity. The noise spectrum of Super-XX film will be shown as an example.

Consideration of Improvements in Condensing Systems for 35mm Projection

R. M. ALTMAN, A. E. NEUMER and H. H. SCHROEDER, *Bausch & Lomb Optical Co., Rochester, N.Y.*

In order to take full advantage of the new *f*/1.8 high-speed projection lenses, faster condensing systems than those now available are required. The design considerations of such systems are discussed and experimental data is given. The increase in screen illumination afforded by these new condensers is accompanied by greater energy at the film gate necessitating more efficient heat control techniques. Optical devices for achieving this are described.

CinemaScope in Drive-in Theatres

RALPH H. HEACOCK, *Radio Corp. of America, Camden, N.J.*

CinemaScope (or any of the other wide-screen, multiple-channel sound, new techniques) presents three important problems to the drive-in theater. The first is a very wide screen. The second is a suitable light source which can provide enough light to illuminate the wide screen acceptably. The third is the possible use of

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The industry test prints by which performance is measured

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The Arriflex 16 is the most advanced camera in the 16mm field. No comparison can be made with any existing equipment. It is in a class by itself... unique for its features, and outstanding for its workmanship.

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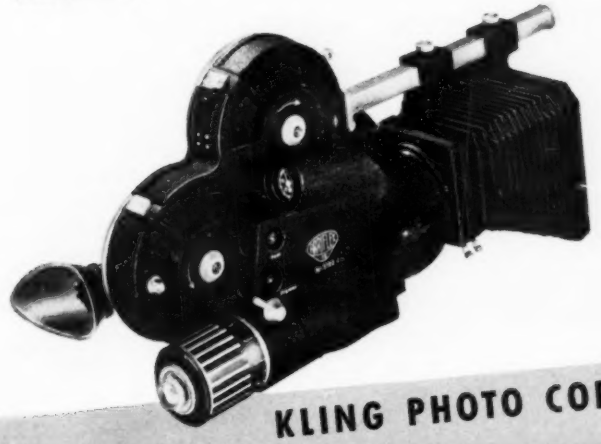
MIRROR REFLEX SHUTTER The most exciting feature of them all: for accurate framing and critical follow-focus, through the taking lens, even during the actual shooting. Image on ground glass is brilliant, uninverted and right-side-up, magnified 10x through a highly corrected optical system. No parallax, and no need for accessory finders.

REGISTRATION PIN Found only in cameras selling for $3000 or more. Automatically engages and locks film during exposure. Assures absolute frame registration, and picture steadiness.

ELECTRIC MOTOR DRIVE No need to stop a scene to wind a spring. Has variable-speed 6-volt DC motor with forward and reverse switch. Operates from portable, rechargeable battery pack, dry cell batteries, or with Transformer-Rectifier Unit on 115 volts AC. Easily interchangeable with Synchronous Motor Unit (available as accessory).

DIVERGENT 3-LENS TURRET Accommodates lenses from 11.5mm extreme wide angle to longest telephotos. Lenses quickly interchangeable. Wide angle and 300mm telephoto can be mounted simultaneously without mechanical or optical interference.



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multiple-channel sound. These problems and their practical application to currently operating drive-in theaters are briefly discussed.

An Improved High-Brightness Screen for Drive-in Theaters

PETRO VLAHOS, *Motion Picture Research Council, Hollywood, Calif.*

Chromaticity Characteristics of Theater Screens

PAUL ZEFF and JOHN P. LIVADARY, *Columbia Pictures Corp., Hollywood, Calif.*

Spatial Sound Effects

J. E. VOLKMANN, *Radio Corp. of America Camden, N.J.*

8:00 P.M. Wide-Screen Processes, Paramount Studio Theatre

An analysis of the factors controlling image quality in wide-screen processes.

FRIDAY OCTOBER 22—CONCURRENT SESSIONS MORNING AND AFTERNOON

10:00 High-Speed Photography, Ambassador Theatre

Simple Electronic Timing Device for High-Speed Photography

WEBSTER BLAKE, *Douglas Aircraft Co., Inc., Santa Monica, Calif.*

A single-pulse simple timing system, to be used in motion picture cameras in the range of 200 to 2000 frames/sec, is discussed. One millisecond resolution is obtained with one neon glow lamp. Application to cameras used in special aircraft installations will be discussed.

A Tracking Twin Telescope Mount

G. A. ECONOMOU, *Sandia Corp., Albuquerque, N.M.*

A Navy twin 40mm hydraulic gun mount has been converted to a tracking telescope mount carrying two 12-in. diameter telescopes and two short focal-length lenses. A radar refocusing system and a thermal expansion correction system have been developed to maintain focus over varying slant ranges and temperatures. The tracking operator has a radar acquisition aid and a bipower sight for acquiring and tracking ballistic objects.

High-Speed Motion Pictures And Sequence Photographs of the Same Event

FRED A. METLEN, *Seattle, Wash.*

Photographic recording of model bomb drop tests in a wind tunnel.

10:00 A.M. General Motion-Picture Photography, Ambassador Theatre

A review is given of the status of motion-picture films for amateur use prior to 1923. Up to that date lack of standardization of film size, the use of the negative-positive method, and cost of apparatus and printing held back extensive use of film for amateur motion pictures. Research in the manufacture of safety acetate film support was started by Eastman Kodak Company in 1906–07 and limited quantities of film were manufactured and sold between 1912 and 1923. Film on safety acetate base, a fundamental requirement for home movies, was introduced in 1912 for a portable projector made by Thomas A. Edison, Inc., and also for equipment made by Pathe Freres, a French firm. Research on film for amateur motion pictures was started in 1914 by Eastman Kodak Co. Subsequent developments of 16mm film, including processing and the use of sound, and the history of 8mm reversal film, are presented.

Early History of Amateur Motion-Picture Film

GLENN E. MATTHEWS and RAIFE G. TARKINGTON, *Eastman Kodak Co., Rochester, N.Y.*

Shrinkage Behavior of Motion-Picture Film

C. R. FORDYCE, J. M. CALHOUN, and E. E. MOYER, *Manufacturing Experiments Div., Eastman Kodak Co., Rochester, N.Y.*

Shrinkage characteristics of both 35mm and 16mm films manufactured by the Eastman Kodak Co. have been evaluated by laboratory measurements and by examination of film in commercial use. Results of these investigations will be presented.

A Light Meter for Printer Control

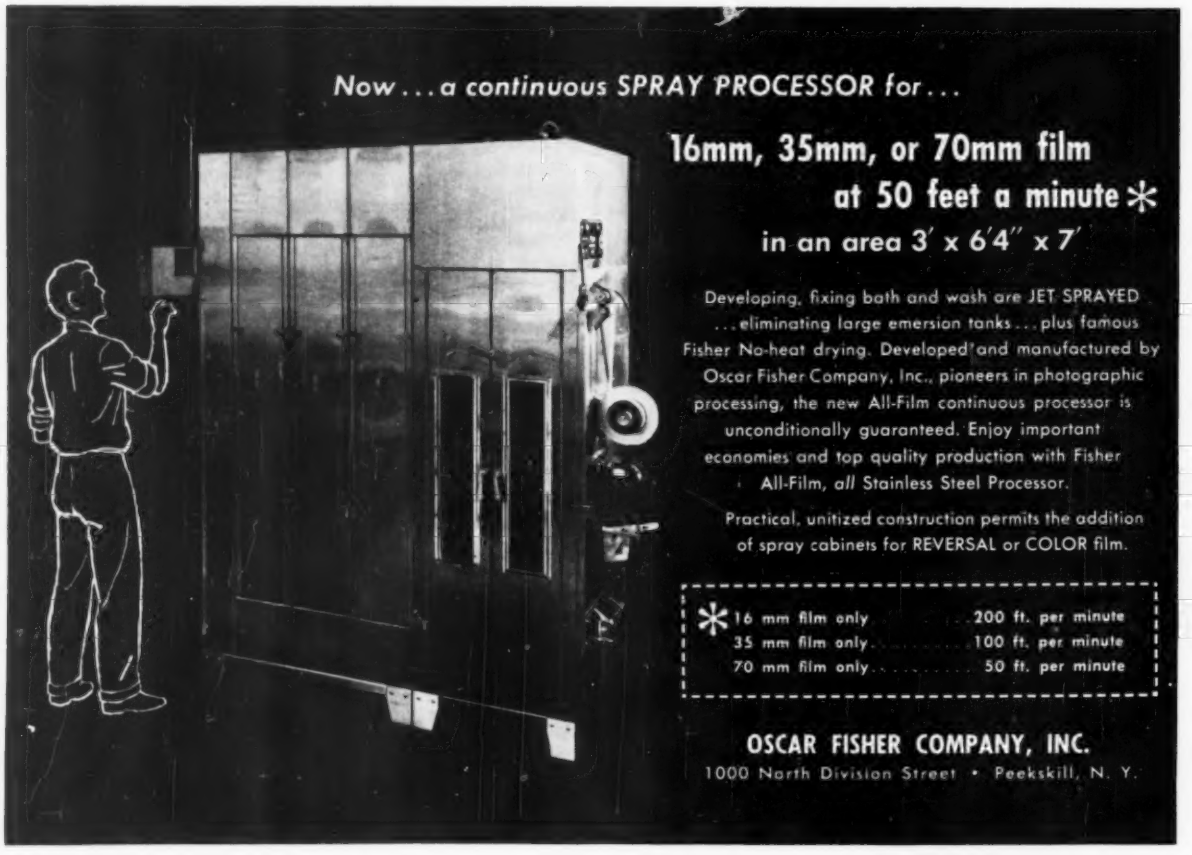
A. J. SANT, M. C. GODDARD, and O. E. MILLER, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*

Because of the increased need for the control of motion picture printers used for printing color films, a simple barrier cell type of light meter was designed for use on release printers. The meter has very good stability and linearity of response. Its sensitivity is very adequate for the intensity levels encountered in release printers. The probe unit contains a filter magazine that permits rapid reading through red, green and blue filters. It was designed to give photocell responses which closely approximate the responses of three sensitive layers of Eastman Color Print Safety Film, Type 5382.

A System for Automatic Additive Printing and Scene Testing of Color Film

FRANK P. HERRNFELD, *Frank Herrnfeld Engineering Corp., Culver City, Calif.*

A system for additive printing of positive color release film is described. The system consists of an additive scene tester, a conversion of a Model D Bell & Howell Printer, and a control system which makes the modified printer completely automatic. The paper treats additive printing only, no attempt being made to compare additive printing to other systems.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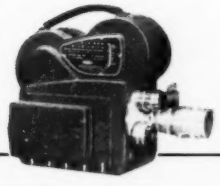

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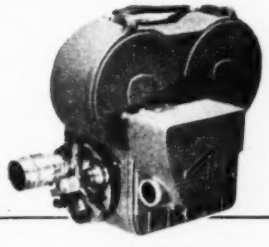

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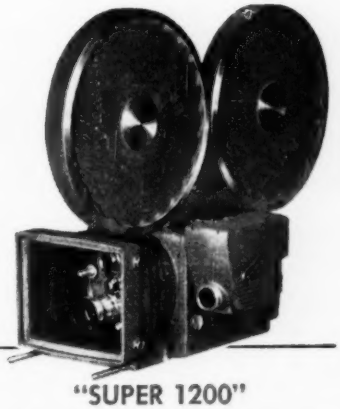

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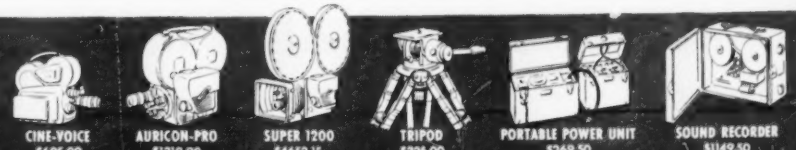

2:00 P.M. High-Speed Photography, Colonial Room

Recording and Assessment of Telemetered Data

RODERICK M. McCLUNG, *U.S. N.O.T.S., China Lake, Calif.*

A method for recording telemetered data on 35mm film and then reading this data by photoelectric methods is discussed.

2:00 P.M. Color Film Sensitometry, Ambassador Theatre

Sensitometers for Color Films

O. E. MILLER, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*

Because of the complexity of color films and processes and the additional quality attributes that must be kept under control, sensitometric test exposures must be of high precision. Exposure conditions should closely simulate the conditions under which the films are used. The chief characteristics that must be controlled are the light intensity, the spectral energy distribution, and the exposure time. Control of a sensitometer is best accomplished by controlling its separate components, the light source, the filters and the timing mechanism. In addition to primary calibration, overall characteristics may be checked frequently by physical photometry or by photographic comparisons with a standard.

Color Densitometers: Performance Characteristics

W. L. BREWER and S. A. POWERS, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*

Color densitometers in motion picture film processing laboratories are used for film processing control, printer control, print film evaluation in terms of its visual characteristics, and negative or intermediate film evaluation in terms of its printing characteristics. Characteristics of a color densitometer which are of interest in considering its suitability for these various applications include density range, measuring geometry, stability, linearity, precision and accuracy. Methods for evaluating each of these performance characteristics are described.

Color Densitometers: Control Methods

M. C. GODDARD and S. A. POWERS, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*

Color densitometers, used for process control and film evaluation, must be controlled if they are to perform satisfactorily. Characteristics to be controlled include spectral sensitivity, measuring geometry, stability, linearity, precision and accuracy. Routine adjustments provide part of this control. Checks through film strips or filters furnish control data. Control materials must be calibrated. The control data may be plotted on control charts, or a single, statistical "go-no-go" gauge may be devised.

Densitometers for Control of Color Motion-Picture Film Processing

JOHN G. FRAYNE and J. H. JACOBS, *Westrex Corp., Hollywood, Calif.*

The widespread use of negative and positive color films now available to the motion picture industry has introduced new, more complicated and more exacting control requirements in the film-processing laboratories. In step with this trend, two new densitometers have been developed. One instrument is intended to provide precise control of the new color picture processes, while the other provides diffuse density measurements of black-and-white, silver-sulfide, and silver-image-with-dye soundtracks. The instruments, their application and performance, are described.

8:00 P.M. Color Session, Academy Award Theatre

Color and Brightness in Projected Color Pictures

RALPH M. EVANS, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*

This formal lecture will include demonstrations of color adaptation and brightness adaptation. Special projection equipment will be used to obtain desired effects.

LADIES PROGRAM—Aside from the Monday Get-Together Luncheon and the Wednesday evening Cocktail Hour, Banquet and Dance, noted above, the exact schedule of events had not been laid down at press time. Detailed arrangements for the Ladies Program are in the hands of Mrs. Philip P. Caldwell and Mrs. John G. Frayne and their planning for a full program of interesting activities in the motion-picture capital is well ahead.

Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Motion Picture Production. Desire position as assistant to producer. Background includes camera experience, some directing in 35mm productions. Age 24. Write: Harry Wuest, 137 Summit Ave., Upper Montclair, N.J.

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16mm Printers, Color Timer, Negative Conformer: Permanent positions for qualified, experienced personnel. Company benefits. Send complete information and small photograph to Byron, Inc., 1226 Wisconsin Ave., Washington 7, D.C.

Motion-Picture Laboratory Technician (Sensitometry), GS-8, $4620 per year. Applicants must have at least 4½ years experience in all phases of motion-picture film processing in black-and-white and color. Position requires ability to handle quality control in processing and to make recommendations for and assist in improving the product. Further information from MCGCER, Headquarters, Air Materiel Command, Wright-Patterson Air Force Base, Ohio.

Photographic Sales Technician. Require competent technician with at least two years' college chemistry and phototechnical school training or equivalent. Must have thorough knowledge of black-and-white, color, studio, and photofinishing techniques. Must show definite interest in sales and willingness to travel. Send brief resume, including approximate salary requirements, to Gerald G. Wood, Ansco, 29 Charles St., Binghamton, N.Y.

Laboratory Technician with years of experience and thorough knowledge of all phases of motion picture laboratory work—as assistant to plant superintendent. **Sensitometric Control Man** with thorough background and experience—full responsibility. **Sound Engineer** to maintain and operate magnetic and optical re-recording equipment. Applicants should contact: Herbert R. Pilzer, Circle Film Laboratories, Inc. 33 West 60th St., New York 23. Tel. Co 5-2180

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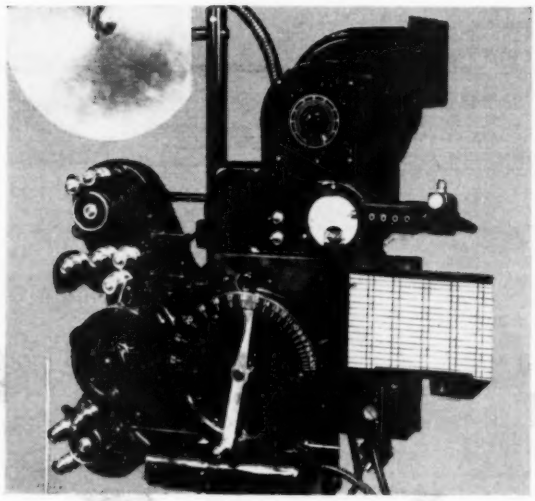

Continuous Printer Model 5205 — adapts for color films, black-and-whites, TV films and for the new 32mm process (printing two 16mm films simultaneously).
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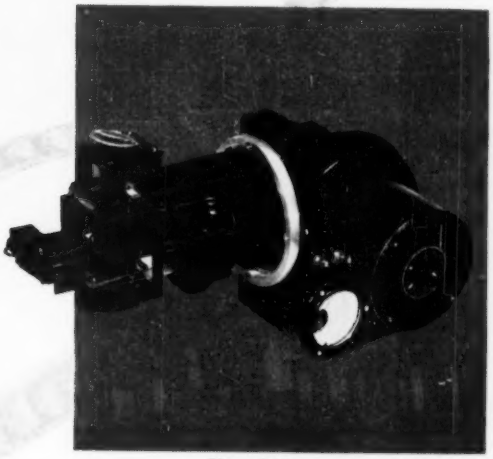

New 300-watt Super-High Intensity Printer Lamp is 194.8 foot-candles brighter than any other 300-watt printer. Included on all new Model 5205 printers, this lamp may be added to B&H printers now in the field. $595

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Meetings

National Electronics Conference, Tenth Annual Conference, Oct. 4–6, Hotel Sherman, Chicago.

Photographic Society of America, Annual Meeting, Oct. 5–9, Drake Hotel, Chicago, Ill.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 11–15, Chicago, Ill.

Audio Engineering Society, Oct. 13–17, New York, N. Y.

Optical Society of America, Oct. 14–16, Ambassador Hotel, Los Angeles

75th Semiannual Convention of the SMPTE, Oct. 18–22, Ambassador Hotel, Los Angeles

Theatre Equipment and Supply Manufacturers' Association (U.S.A.), Annual Trade Show, with exhibits, Oct. 31–Nov. 4, Conrad Hilton Hotel, Chicago.

Adult Education Association, National Conference, Nov. 5–10, Hotel Morrison, Chicago.

National Electrical Mfrs. Assn., Nov. 8–11, Ambassador Hotel, Atlantic City, N. J.

Acoustical Society of America, Nov. 18–20, Austin, Texas

77th Semiannual Convention of the SMPTE, Apr. 17–22, 1955, Drake Hotel, Chicago, Ill.

The International Commission on Illumination is to hold its next international conference in Zurich, Switzerland, June 13–22, 1955. Offers of papers should be addressed to the Chairman of the Papers Committee (A. A. Brainerd, 1015 Chestnut St., Philadelphia 7). Manuscripts must be in the hands of the Central Bureau between Oct. 1 and Dec. 31, 1954.

Biological Photographic Association, Annual Meeting, Aug. 30–Sept. 2, 1955, Wisconsin Hotel, Milwaukee.

78th Semiannual Convention of the SMPTE, Oct. 8–12, 1955 (50th year), Lake Placid Club, Essex County, N.Y.

Photographic Society of America, 1955 Convention, Oct. 5–8, 1955, Statler-Pierce Hotel, Boston, Mass.

79th Semiannual Convention of the SMPTE, Apr. 29–May 4, 1956, Hotel Statler, New York

80th Semiannual Convention of the SMPTE, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles

81st Semiannual Convention of the SMPTE, Apr. 29–May 3, 1957, Shoreham Hotel, Washington, D. C.

82nd Semiannual Convention of the SMPTE, Oct. 6–11, 1957, Hotel Statler, New York

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April Journal.

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